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ABSTRACT

Teacher and student editions and a student workbook for fundamentals of welding comprise the first of six in a series of competency-based instructional materials for welding programs. Introductory pages in the teacher edition are training and competency profile, instructional/task analysis, basic skills icons and classifications, basic skills matrix, and tools, equipment, and materials list. Teacher pages include unit contents, suggested activities, answers to assignment sheets, written test with answers, teacher supplements, and transparency masters. The eight units are welding orientation, general safety, welding safety and first aid, welding tools and equipment, basic metals and metallurgy, basic math and measuring, welding print reading, and basic welding joints and symbols. The student edition contains some or all of these components for each unit: unit contents, learning activities sheet, objective sheet, information sheet, and student supplements. A student workbook contains assignment sheets and job sheets for all eight units. (YLB)

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ED 449 374

Fundamentals of Welding. Second Edition. Teacher Edition [and] Student Edition [and] Student Workbook

Clarence Fortney
Mike Gregory
Larry New

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Second Edition

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MAVCC

Teacher Edition

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Fundamentals of Welding

Second Edition

Teacher Edition

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Units of Instruction

Unit 1: Welding Orientation
Unit 2: General Safety
Unit 3: Welding Safety and First Aid
Unit 4: Welding Tools and Equipment
Unit 5: Basic Metals and Metallurgy
Unit 6: Basic Math and Measuring
Unit 7: Welding Print Reading
Unit 8: Basic Welding Joints and Symbols

Foreword

Fundamentals of Welding is the first in a series of six welding publications and serves as the foundation for students enrolled in a welding program. An additional unit on "General Safety" has been added to increase student knowledge of safe practices and procedures. This new unit, along with Unit 3, "Welding Safety and First Aid," merit review at regular intervals throughout the instructional process. The materials about distortion control should be taught in conjunction with any of the arc or oxyfuel welding processes. The units of instruction on "Welding Print Reading" and "Basic Welding Joints and Symbols" present applications that students will find challenging as they learn to read and interpret welding symbols.

These instructional materials have been designed to assist teachers in improving instruction. Every effort has been made to make these materials basic, readable, and usable. The teacher will need to develop instructional strategies for motivating their students, and localizing, individualizing, and supplementing the instructional materials. Suggestions for teaching the unit, suggested supplemental resources to include internet resources, a criterion-referenced test, teacher supplements, and transparency masters are included in the teacher pages for each unit of instruction.

This edition of the *Fundamentals of Welding* includes a student workbook that contains assignment sheets and job sheets for all eight units. Student workbooks can be purchased individually each year to provide new students with the assignment and job sheets needed to master the course.

It should be emphasized that students need to be aware of professional organizations and take an active part in them as much as possible. Professional organizations, as well as career and technology education, are excellent avenues for continuing education within the welding trade.

This welding series is crosswalked to the state of Oklahoma's duty/task list. However, a crosswalk to the duty/task list is not included in the *Fundamentals of Welding* because of the general nature of its objectives. Crosswalks will be included in the other five books of the Welding series.

Emmett Eary, Chair
Board of Directors
Multistate Academic and
Vocational Curriculum
Consortium

Clark R. Harris
Executive Director
Multistate Academic and
Vocational Curriculum
Consortium

Acknowledgments

Appreciation is extended to those individuals who contributed their time and talent to the development of *Fundamentals of Welding*.

The contents of this publication were initially planned and reviewed by the following committee members:

Charley Brantley	Wichita, Kansas
James Buhler	Watertown, South Dakota
Joe Don Davidson	Perry, Oklahoma
Larry New	North Little Rock, Arkansas
Dave Roberts	Denver, Colorado
Robert Pint	Winthrop, Iowa
Kenneth Powers	Natchitoches, Louisiana
Jack Runge	Lincoln, Nebraska

A special thank you goes to the many manufacturers whose procedures and illustrations have been used as models to authenticate and enhance our instructional materials. Another thank you goes to the American Welding Society and the Lincoln Electric Company for their contributions in helping us maintain technical accuracy.

Special thanks are also extended to Stacy Lee, Electronic Publishing Technician, for her hard work and ingenuity in completing artwork and digitizing this edition, and John Knapp, Welding Instructor, Tulsa Technology Center, for allowing us to use his welding shop as a photography studio.

Appreciation is extended to employees of the Print Shop of the Oklahoma Department of Career and Technology Education for printing this text.

Thanks are also extended to Jane Huston, MAVCC Curriculum Coordinator.

Use of This Publication

Fundamentals of Welding is available in both a teacher and student edition. The contents of these materials are tied to measurable and observable learning outcomes that were identified and validated by the welding advisory committee, comprised of business/industry representatives and teachers.

Teacher Edition

The complete teacher edition consists of introductory pages, teacher pages, the student edition, and the student workbook. The introductory and teacher pages are loose-leaf and three-hole punched. The student edition is spiral bound, and the student workbook is perfect bound with the pages perforated for easy removal. Each are divided into units of instruction that may be broken into more than one lesson or class period. For added flexibility, each unit in the teacher pages is individually numbered beginning with a T for teacher page, followed by the unit number and page number.

Examples:

Page 17 of Unit 3 in the teacher pages is represented as T 3–17.

MAVCC—*Fundamentals of Welding*	T 3–17

Pages in the student workbook are sequentially numbered beginning with page 1.

MAVCC—*Fundamentals of Welding*	Page 1

Page 7 of Unit 5 in the student edition is represented as Page 5—7.

MAVCC—*Fundamentals of Welding*	Page 5–7

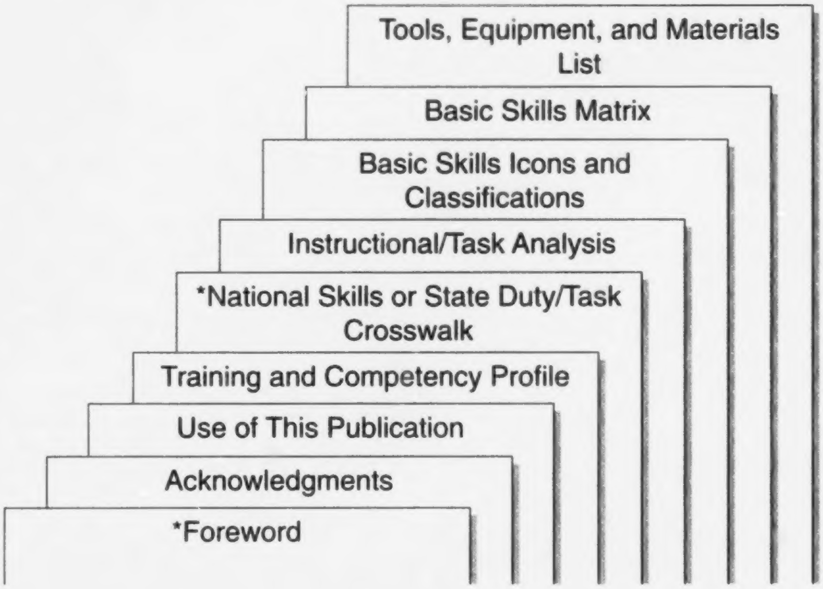
Use of This Publication

For group instruction, the teacher should determine the best way to teach each objective and allow for student participation. For self-paced or individualized instruction, students should be provided with opportunities to become involved in planning and being responsible for their own education. Careful study of each unit of instruction by the teacher will help to determine the following:

- amount of material that can be covered in each class period;
- supplies and materials required for assignment sheets and job sheets;
- resource people who must be contacted;
- supplementary materials to be ordered;
- skills that must be demonstrated and the amount of class time needed for demonstrations; and
- amount of class time needed for student practice and return demonstrations of mastered skills.

Teachers are encouraged to localize and personalize these materials to meet the needs of individual students, the community, and prospective employers.

Introductory Pages


Tools, Equipment, and Materials List
Basic Skills Matrix
Basic Skills Icons and Classifications
Instructional/Task Analysis
*National Skills or State Duty/Task Crosswalk
Training and Competency Profile
Use of This Publication
Acknowledgments
*Foreword

*Designates items that may not appear in every publication

Use of This Publication

In addition to general information, such as the table of contents, acknowledgments, and the use of this publication, the following tools have been provided to assist administrators and teachers in planning for instruction.

☐ **Training and Competency Profile.** This form may be copied and used to record information about each student, such as enrollment dates, class attendance, and work experience, and to document the student's mastery of specific job competencies. It can also be used to provide information about the student's qualifications to potential employers and/or for entry into advanced training programs.

☐ **National Skills and/or State Duty/Task Crosswalk.** This document identifies the national and/or state skill standards covered in this publication and lists specifically where these skills are located by unit number and objective.

☐ **Instructional/Task Analysis.** This document provides a quick review of the contents of this publication by identifying the cognitive skills (what the student should know) and psychomotor skills (what the student should be able to do) addressed in each unit of instruction.

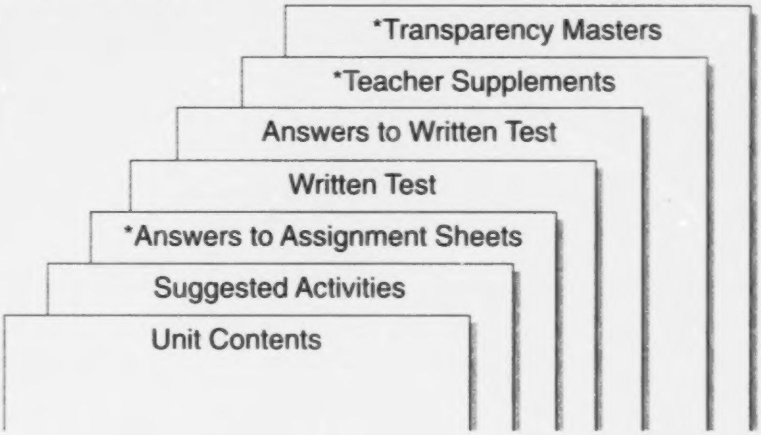
☐ **Basic Skills Icons and Classifications.** This page provides a reference guide of the graphic symbols that are used to identify the basic academic and workplace skills included in each assignment sheet and job sheet.

☐ **Basic Skills Matrix.** This document graphically summarizes the academic and workplace skills training included in the instructional materials, unit by unit. It should be helpful to teachers in planning for instruction, and to administrators as documentation that basic skills are being taught as part of the vocational training.

☐ **Tools, Equipment, and Materials List.** This document provides a comprehensive list of those items needed in a vocational program for students to complete training. It also can assist administrators and teachers in determining program costs.

Use of This Publication

Teacher Pages



*Designates components that may not appear in every unit of instruction

Teachers should study the teacher and student pages before introducing the unit, allowing enough time to obtain supplemental materials and to contact outside resource persons.

☐ **Suggested Activities.** This component assists teachers during the preparation stage of the teaching/learning process by providing an instructional plan, teaching suggestions, a list of references used in the development of each unit, and a list of suggested supplemental resources (books, posters, pamphlets, videotapes, computer software, and Internet sites) that may be used to enhance instruction.

Instructions for evaluating student performance on the assignment sheets and job sheets are also included in the suggested activities section. Teachers should select and discuss with students the rating scale that will be used.

☐ **Answers to Assignment Sheets.** An answer key is provided, when applicable, to assist the teacher in evaluating student performance on a given assignment.

☐ **Written Test.** This component provides criterion-referenced evaluation of every cognitive objective listed in the unit of instruction, and serves as both a pretest and posttest to assist teachers in measuring each student's competency gains. (Assignment sheet and job sheet objectives are not evaluated on the written test.) If the teacher has added, deleted, or modified any objectives, appropriate changes should be made to both the test and answers to the written test.

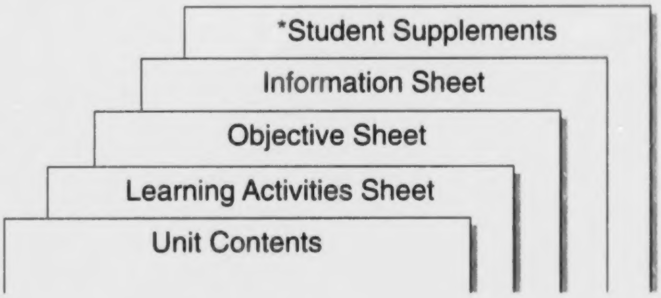
Tests may be divided into shorter tests covering three or four objectives at a time and given soon after those objectives have been covered. A selection of test items from the units covered may be used for a final test at the end of each term if desired. The written test is included in the teacher edition only and should be duplicated for student use.

☐ **Answers to Written Test.** An answer key is provided to assist the teacher in evaluating student performance on the written test.

☐ **Teacher Supplements.** These are optional materials for the teacher to use. They have three purposes: to provide the teacher with higher-level materials to stretch the advanced student; with remedial information or practice to assist the less-advanced student; and with state-of-the-art information in which the teacher may not have a background or with information that is not readily available in other books. Some teacher supplements may be duplicated for student use and are marked accordingly.

☐ **Transparency Masters.** These overheads are used to direct the students' attention to the topic of classroom discussion. Transparencies allow the student to see as well as hear the information being presented, thus reinforcing the learning process. They may provide illustrations, charts, schematics, or additional information needed to clarify and reinforce objectives included in the unit of instruction. Some of these items may also appear with the appropriate objectives in the information sheet in the student edition. The teacher may make acetate copies from the masters or, in most cases, complete transparency sets are available for purchase.

Student Edition



*Designates a component that may not appear in every unit of instruction

For best results, students should be provided with a copy of the student edition and should be allowed to take notes in the margins as additional information is provided by the instructor or as the student acquires additional information through library or Internet research.

☐ **Learning Activities Sheet.** This component can be used to guide the student in self-paced or individualized programs, and in other programs provides the student with an overview of how components interface within the unit. It's designed to guide the student through the required and optional components in the student edition (objective sheet, information sheet, and student supplements). The teacher is encouraged to use this component as a model and modify the learning steps as needed to incorporate resources available in the classroom (videotapes, computer software, magazines, etc.) and to address instructional strategies that may be needed to enhance learning for each student.

The following icons will be used on the learning activities sheet to denote steps that require additional resources:

📖 Read a book, magazine, or journal article

💻 Use a CBT program or other software application

🌐 Access a site on the World Wide Web

🖥 Look at PowerPoint® or other computer presentation

📼 Watch a videotape

☐ **Objective Sheet.** This component summarizes each unit for the student and teacher. The objective sheet is based on established performance objectives that state the goals for successful completion of a unit of instruction. Objectives are stated in two forms: unit objectives that state the expected performance of each student after completion of the unit and specific (enabling) objectives that state what the student must be able to do to reach the unit objective.

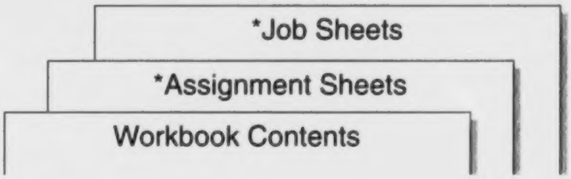
The objectives should be stressed throughout the teaching/learning process. This will help answer any questions concerning performance requirements for each instructional unit. The objectives can also help determine teaching strategies and instructional methods.

Teachers should modify, delete, or add objectives in order to meet the needs of the students and community. When objectives are added, the teacher should remember to supply the needed information, assignment and/or job sheets, and criterion-referenced test items to cover the new objectives.

☐ **Information Sheet.** This component provides the student with the essential information for meeting the cognitive objectives in the unit. Teachers will find that the information sheet serves as an excellent guide for presenting background knowledge necessary to develop the skills specified in the unit objective. Students should read the information sheet before the information is discussed in class. Space is provided in the margins for students and teachers to add notes that clarify and/or expand upon the information presented.

☐ **Student Supplements.** This component is included in a unit of instruction when additional information is needed in order for students to complete one or more of the assignment and/or job sheets. Students are not directly tested over the information presented in a supplement; however, their ability to apply this information may be evaluated in the completion of assignment and/or job sheets.

Student Workbook



*Designates components that may not appear in every unit of instruction.

The student workbook is an integral part of the student materials and should be provided to each student. It contains the pen-and-paper exercises and skill tests necessary for student mastery of the course.

☐ **Assignment Sheets.** The assignment sheets address the learning levels at or above the application level of Bloom's taxonomy. They provide students with an opportunity to use higher-order thinking skills, such as problem solving, synthesizing, analyzing, and evaluating. In addition, they may provide additional opportunities for students to develop their language skills.

Assignment sheets can be paper-and-pencil activities, as well as those using computer software, videotapes, models, handouts, or other resources as appropriate. Criteria are provided to evaluate student performance objectively.

☐ **Job Sheets.** Job sheets are designed as skill tests and give the instructor direction as to the psychomotor skills to be taught, and provide the criteria to evaluate student performance objectively. They also help provide potential employers with a picture of the skills being taught during training and the performances that might be reasonably expected from an individual who has completed the training.

Use of This Publication

The teacher should provide students with a copy of each job sheet and/or the procedure's manual and/or job specifications when necessary. The teacher should also discuss the equipment and materials that will be needed for the job and the criteria that will be used to evaluate the student's performance, and demonstrate the procedure prior to having students practice the procedure. Safety should be stressed as part of each demonstration.

When a student is ready to be evaluated, the teacher should follow the instructions for evaluating student performance which may be found in the suggested activities component of the teacher unit.

As you use these instructional materials we hope that you will find that they contribute to the quality of your program. If any problems occur or if you have any suggestions for improvement of the materials, please write us at 1500 West Seventh Avenue, Stillwater, OK 74074-4364, call us at 800-654-3988, or E-mail us at mavcc@okcareertech.org.

Training and Competency Profile

Student Information

Program ____________________ Instructor ____________________

Name ____________________ Soc. Sec. No. ____________________

Address ______________________________ Phone ______________

Grade ____________ School ______________________________

Allergies/Disabilities that might require special accommodation for training (please specify)

____

In case of emergency, contact ____________________ Phone ______________

Record of Enrollment

Date of Enrollment ____-____-____ Total Class Hours________ Total Hours Absent________

Date of Withdrawal ____-____-____ Total On-the-Job Training Hours________ Total Hours Tardy________

Date of Completion ____-____-____ Total Lab Hours________

On-the-Job Training/Work Experience

Place of Employment ____________________ Address ____________________

Supervisor's Name ____________________ Phone ____________________

Duration of Employment ____________________ Job Title ____________________

Job Responsibilities ______________________________

Place of Employment ____________________ Address ____________________

Supervisor's Name ____________________ Phone ____________________

Duration of Employment ____________________ Job Title ____________________

Job Responsibilities ______________________________

Training and Competency Profile

Student Evaluation

Directions: Evaluate the student using the rating scale below. Write the appropriate number to indicate the degree of competency achieved. The descriptions associated with each of the numbers focuses on a level of student performance for each of the tasks listed. The written test scoreline is provided for optional teacher use. It may not be applicable in all cases.

Rating Scale: Option A

4	Skilled—Can perform job with no additional training
3	Moderately Skilled—Has performed job during training program; limited additional training may be required.
2	Limited Skill—Has performed job during training program; additional training is required to develop skill.
1	Unskilled—Is familiar with process, but is unable to perform job.
0	No Exposure—No information or practice provided during training program, complete training required.
NA	Non-applicable.

Rating Scale: Option B

Yes—Can perform with no additional training
No—Is unable to perform satisfactorily

Unit 1: Welding Orientation

_____ 1. Identify Welding Processes
_____ 2. Compare Employment Opportunities in Welding
_____ 3. ______________________
_____ Written Test Score

Unit 2: General Safety

_____ 1. Complete the Student Safety Pledge Form
_____ 2. Interpret a Material Safety Data Sheet
_____ 3. Draw a Layout of your School and Apply the Safety Color Code
_____ 4. Determine Correct Fire Extinguishers to use for Various Situations
_____ 5. Identify and Correct Safety Violations
_____ 6. Operate a Fire Extinguisher
_____ 7. Lift a Heavy Object Properly
_____ 8. Place and Climb a Ladder Safely
_____ 9. ______________________
_____ Written Test Score

Unit 3: Welding Safety and First Aid

_____ 1. Determine Basic First Aid Measures for Given Emergency Situations
_____ 2. ______________________
_____ Written Test Score

Unit 4: Welding Tools and Equipment

_____ 1. Identify Basic Hand Tools
_____ 2. Identify Basic Power Tools and Equipment
_____ 3. ______________________
_____ Written Test Score

Unit 5: Basic Metals and Metallurgy

_____ 1. Identify Selected Metals by Appearance, Color, and Corrosion Characteristics
_____ 2. Conduct Magnet Tests to Identify Common Metals Used for Welding
_____ 3. Conduct Chisel Tests to Identify Common Metals Used for Welding
_____ 4. Conduct Spark Tests to Identify Common Metals Used for Welding
_____ 5. ______________________
_____ Written Test Score

Training and Competency Profile

Unit 6: Basic Math and Measuring

_____ 1. Add, Subtract, Multiply, and Divide Fractions
_____ 2. Add, Subtract, Multiply, and Divide Decimal Equivalents
_____ 3. Convert Fractions to Decimal Form, Change Fractions to a Common Denominator, and Reduce Fractions to Lowest Terms
_____ 4. Write Fractions as Decimals and Percents
_____ 5. Write Percents as Fractions and Decimals
_____ 6. Write Decimals as Fractions and Percents
_____ 7. Make Conversions with a Decimal Equivalent Chart
_____ 8. Make Conversions with an Inches-to-Decimal Conversion Chart
_____ 9. Measure Distances with 1″, 1/2″, and 1/4″ Graduations
_____10. Measure Distances with 1/4″ and 1/8″ Graduations
_____11. Measure Distances with 1/8″ Graduations
_____12. Measure Distances with 1/16″ Graduations
_____13. Make Conversions with an English-Metric Conversion Chart
_____14. Calculate Area of Geometric Figures
_____15. Adjust a Bevel Square to a 45° Angle Using a Framing Square, a Combination Square, and a Protractor
_____16. Form 90° and 45° Angles with a Combination Square and Draw Parallel Lines on Metal Stock
_____17. ______________________________
_____ Written Test Score

Unit 7: Welding Print Reading

_____ 1. Construct a Top View
_____ 2. Construct a Front View
_____ 3. Construct a Right Side View
_____ 4. Construct Missing Hidden Lines
_____ 5. Interpret Tolerance Dimensions in Decimals, Fractions, and Degrees
_____ 6. Construct Missing Visible and Hidden Lines
_____ 7. Make a Three-View Sketch
_____ 8. Construct Adjacent Parts in an Assembly Section
_____ 9. ______________________________
_____ Written Test Score

Unit 8: Basic Welding Joints and Symbols

_____ 1. Identify Basic Weld Symbols
_____ 2. Interpret Basic Welding Symbols
_____ 3. Interpret Working Welding Symbols
_____ 4. Draw Welding Symbols for Given Specifications
_____ 5. Interpret a Welding Print and Welding Procedure Specifications
_____ 6. ______________________________
_____ Written Test Score

Instructional/Task Analysis

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 1: Welding Orientation

1. Terms and definitions
2. Welding processes
3. Brazing and braze welding
4. Cutting processes
5. Where welders work
6. What welders earn
7. The job outlook for welders
8. What it takes to become a good welder
9. Career opportunities
10. Standards, codes, and specifications
11. Standards and their importance to the welding industry
12. Identify welding processes
13. Compare employment opportunities in welding

Unit 2: General Safety

1. Terms and definitions
2. Guidelines for dressing safely on the job
3. General job and shop safety rules
4. Hazard Communication
5. Storage of hazardous materials
6. Facts about the purposes of material safety data sheets
7. Colors of the safety color code and their uses
8. Safety tags and their color coding
9. Accident prevention signs, their colors and uses
10. Components of the fire triangle
11. Types of fires and their classifications
12. General types of fire extinguishers and their uses

Instructional/Task Analysis

Unit 2: General Safety (continued)

Related Information: What the Student Should Know

13. Fire extinguisher markings and their meanings
14. Fire extinguisher general operation instructions that follow the letters P-A-S-S
15. Causes of back injuries and their contributing factors
16. Guidelines for lifting and moving items safely
17. Guidelines for preventing slips, trips, and falls
18. Rules for using ladders safely
19. Instances when lockout devices should be used
20. Three types of fall protection systems
21. Terms related to confined space entry
22. Environmental contaminants requiring the use of a respirator

Application: What the Student Should Be Able to Do

23. Complete the student safety pledge form
24. Interpret a material safety data sheet
25. Draw a layout of your school and apply the safety color code
26. Determine correct fire extinguishers to use for various situations
27. Identify and correct safety violations
28. Operate a fire extinguisher
29. Lift a heavy object properly
30. Place and climb a ladder safely

Unit 3: Welding Safety and First Aid

1. Terms and definitions
2. The ALWAYS rules for welding safety
3. The NEVER rules for welding safety
4. Personal protective clothing required for welding
5. Wearing proper eye protection
6. Hazards from arc rays
7. Types of welding hoods
8. Guidelines for duty cycle safety
9. Important rules for handling welding cables and gas and coolant hoses
10. Guidelines for oxygen safety
11. Guidelines for acetylene safety
12. Guidelines for other fuel gas safety
13. Guidelines for shielding gas safety
14. Rules for storing compressed gas cylinders
15. Rules for moving compressed gas cylinders

Unit 3: Welding Safety and First Aid (continued)

Related Information: What the Student Should Know	Application: What the Student Should Be Able to Do
16. Steps for handling any emergency situation 17. Guidelines for first aid emergencies 18. Basic first aid procedures for various emergency situations	19. Determine basic first aid measures for given emergency situations

Unit 4: Welding Tools and Equipment

Related Information: What the Student Should Know	Application: What the Student Should Be Able to Do
1. Terms and definitions 2. Driving and chipping tools, their characteristics and uses 3. Chisels, punches, and pry bars, and their uses 4. Characteristics and uses of files 5. Types and uses of wire brushes 6. Vise-grip® clamps and their uses 7. Holding and anchoring tools and their uses 8. Alignment tools and their uses 9. Types of jacks and their uses 10. Pulling and lifting tools, their characteristics and uses 11. Measuring tools and their characteristics and uses 12. Layout tools, their characteristics and uses 13. Turning tools and wrenches and their uses 14. Pliers and their uses 15. Manual cutting and shaping tools and their uses 16. Manually-operated shop tools, their characteristics and uses 17. Power equipment, their characteristics and uses 18. Power saws, their characteristics and uses 19. Positioning equipment, their characteristics and uses 20. Rules for hand tool safety 21. Rules for safe use of power tools and equipment 22. Rules for tool and equipment maintenance	23. Identify basic hand tools 24. Identify basic power tools and equipment

Related Information: What the Student Should Know	Application: What the Student Should Be Able to Do

Unit 5: Basic Metals and Metallurgy

1. Terms and definitions
2. Advantages of proper metal identification
3. Basic metals and alloys, their properties and their definitions
4. Metal identification tests and their characteristics
5. Mechanical properties of metals and their characteristics
6. Mechanical strengths and their characteristics
7. Physical properties of metals and their characteristics
8. Steel identification systems and their characteristics
9. Carbon steel classifications, characteristics, and typical uses
10. Principal steel alloys and their uses
11. Alloy steel classifications, characteristics, and typical uses
12. Iron classifications, characteristics, and typical uses
13. Guidelines for identifying metals by color and characteristics
14. Aluminum, its characteristics and uses
15. Basics of the commercial system for identifying aluminum
16. The 1XXX group commercial identification system
17. The 2XXX plus group commercial identification system
18. Other elements of commercial aluminum identification
19. Aluminum quality designations and their meanings
20. Steps in using the commercial system to identify aluminum

Unit 5: Basic Metals and Metallurgy (continued)

Related Information: What the Student Should Know

21. Nonferrous metals and their typical uses
22. Guidelines for testing properties of metals
23. Equipment requirements for spark testing
24. Guidelines for spark testing
25. Characteristics of residual stresses
26. Causes of residual stresses and distortion
27. Guidelines for controlling expansion and contraction
28. Routes for heat expansion from basic welds
29. Longitudinal and transverse stress in basic welds
30. Heat applications and their uses in weld quality control
31. Guidelines for preheating in special conditions
32. Methods of preheating and postheating and their applications
33. Torch preheating techniques and their applications
34. Types of steels and their recommended preheat temperatures
35. Temperature-sensing devices and their uses
36. Methods for controlling distortion with the welding process
37. Guidelines for controlling distortion with mechanical means
38. Methods of controlling distortion with restraining devices

Application: What the Student Should Be Able to Do

39. Identify selected metals by appearance, color, and corrosion characteristics
40. Conduct magnet tests to identify common metals used for welding
41. Conduct chisel tests to identify common metals used for welding
42. Conduct spark tests to identify common metals used for welding

Unit 6: Basic Math and Measuring

1. Terms and definitions
2. Basic mathematical terms and their definitions
3. Benefits of decimal equivalent charts
4. Benefits of an inches-to-decimal conversion chart

Instructional/Task Analysis

Unit 6: Basic Math and Measuring (continued)

Related Information: What the Student Should Know

5. Place values of decimal equivalents and how to express them
6. Type of rules and their graduations
7. Steps in reading a scale
8. Terms used in geometry
9. Types of geometric figures and their descriptions
10. Units of measure and their equivalents
11. Formulas for calculating the perimeter of squares, rectangles, and triangles
12. Formulas for calculating the area of geometric figures
13. English-metric conversion charts and how to use them
14. Methods of sizing commonly used steel stock

Application: What the Student Should Be Able to Do

15. Add, subtract, multiply, and divide fractions
16. Add, subtract, multiply, and divide decimal equivalents
17. Convert fractions to decimal form, change fractions to a common denominator, and reduce fractions to lowest terms
18. Write fractions as decimals and percents
19. Write percents as decimals and fractions
20. Write decimals as fractions and percents
21. Make conversions with a decimal equivalent chart
22. Make conversions with an inches-to-decimal conversion chart
23. Measure distances with 1″, 1/2″, and 1/4″ graduations
24. Measure distances with 1/4″ and 1/8″ graduations
25. Measure distances with 1/8″ graduations
26. Measure distances with 1/16″ graduations
27. Make conversions with an English-metric conversion chart
28. Calculate area of geometric figures
29. Adjust a bevel square to a 45° angle using a framing square, a combination square, and a protractor
30. Form 90° and 45° angles with a combination square and draw parallel lines on metal stock

Unit 7: Welding Print Reading

1. Terms and definitions
2. Basic lines and their uses
3. Basic views
4. Isometric and oblique drawings
5. Problems relating to dimensioning
6. Problems relating to tolerancing

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 7: Welding Print Reading (continued)

7. Methods of dimensioning
8. Bevels and chamfers
9. Reduction and enlargement scales
10. Types of holes
11. Types of threads
12. Types of section views
13. Other symbols
14. Structural shapes
15. Requirements for a formal bill of materials
16. Requirements for an informal bill of materials

17. Construct a top view
18. Construct a front view
19. Construct a right side view
20. Construct missing hidden lines
21. Interpret tolerance dimension in decimals, fractions, and degrees
22. Construct missing visible and hidden lines
23. Make a three-view sketch
24. Construct adjacent parts in an assembly section

Unit 8: Basic Welding Joints and Symbols

1. Terms and definitions
2. Basic parts of a welding symbol
3. Arrow side, other side significance
4. Arrow line variations
5. Difference between weld symbols and welding symbols
6. Supplementary symbols
7. Contour and finish symbols
8. Information in a welding symbol tail
9. Basic welding joints
10. Basic welding symbols
11. Basic rules for locating dimensions
12. Additional symbols for fillet welds
13. Nondestructive testing symbols
14. Procedures for fitting up and welding structural shapes

15. Identify basic weld symbols
16. Interpret basic welding symbols
17. Interpret working welding symbols
18. Draw welding symbols for given specifications
19. Interpret a welding print and welding procedure specifications

Basic Skills Icons and Classifications

To assist teachers and students in identifying and documenting where academic and workplace skills are being taught, MAVCC has adopted a system that uses icons and a list of specific tasks to identify the skill or skills that are used in each assignment sheet and job sheet.

A matrix for each of the ten broad skill areas has been included in this edition and reflects key elements from *What Work Requires of Schools: A SCANS Report for America 2000*, a 1991 study by the U.S. Department of Labor; *Workplace Basics: The Skills Employers Want*, a three-year study conducted jointly by the American Society for Training and Development (ASTD) and the United States Department of Labor (DOL); and other national and state sources.

Each of the ten broad skill areas—reading, writing, mathematics, science, oral communication, interpersonal or relating, critical thinking, employability, social studies, and technology—is represented by the icon presented below.

Reading Skills

- Reading Comprehension
- Research/Reference
- Functional Reading

Writing Skills

- Language
- Composition
- Research
- Functional Writing

Math Skills

- Operation and Calculation
- Math Application
- Data Analysis and Display
- Functional Math

Basic Skills Icons and Classifications

Science Skills

- General Science
- Life Science
- Physical Science
- Earth Science

Oral Communication Skills

- Oral Presentation
- Listening
- Interactive Communication

Interpersonal or Relating Skills

- General Relating
- Teamwork/Cooperation
- Leadership/Influence

Critical Thinking Skills

- Cognitive Activities

Employability Skills

- Job Search/Selections
- Job Acquisition/Development
- Resource Management
- Job Safety

Social Studies Skills

- Information Analysis
- Social Studies Application
- Functional Social Studies

Technology Skills

- Selection
- Application
- Maintenance/Troubleshooting

Reading Skills

Reading Comprehension

- Gain factual information
- Distinguish fact, opinion, and inference
- Recognize stereotyping and bias
- Recognize propaganda
- Analyze cause and effect
- Draw conclusions
- Make generalizations
- React to written material
- Apply word analysis techniques
- Analyze and apply what has been read to specific task
- Comprehend written information for main ideas
- Determine what information is needed

Research/ Reference

- Select useful resources
- Locate resources
- Find materials in library
- Use standard references
- Use in-book reference tools
- Use audiovisual media
- Use computer database
- Use magazines and newspapers

Functional Reading

- Interpret forms and records
- Follow written instructions
- Interpret graphics and symbols
- Interpret abbreviations/acronyms
- Read aloud
- Apply/understand technical words that pertain to subject

Writing Skills

Language

- Use standard grammar, spelling, and capitalization
- State ideas clearly

Composition

- Use complete sentences
- Develop preliminary outline
- Use topic sentences
- Use introductory/closing paragraphs
- Compose reports
- Compose essays
- Proofread and edit
- Construct graphics and symbols

Research

- Take notes
- Use note cards
- Create bibliography
- Use footnotes
- Outline material

Functional Writing

- Complete forms and records
- Write instructions
- Write letters
- Write job applications
- Write resumes
- Use word processing
- Use computer graphics
- Use content area vocabulary

Math Skills

Operation and Calculation

- Round off numbers
- Estimate answers
- Use scientific notations
- Use exponential notations
- Calculate with whole numbers
- Calculate with fractions
- Calculate with decimals
- Convert whole numbers to fractions
- Convert whole numbers to decimals
- Solve numerical expressions
- Solve formulae and equations
- Obtain squares and square roots
- Convert units of measure
- Perform metric calculations

Math Application

- Solve word problems
- Select/apply mathematical formula
- Select/apply mathematical procedure
- Use English and metric measures
- Solve time/rate/distance problems
- Solve ratio/proportion problems
- Solve percent problems
- Apply techniques of scaling
- Apply algebra principles
- Apply geometry principles
- Apply trigonometry principles

Data Analysis and Display

- Interpret charts and tables
- Interpret graphs
- Collect/record data
- Apply sampling techniques
- Apply principles of probability
- Construct charts and tables
- Construct graphs
- Calculate statistics
- Interpret statistics
- Interpret plans/blueprints
- Draw facility to scale

Math Skills (Continued)

Functional Math

- Make measurements
- Perform banking transactions
- Make change
- Solve practical problems
- Calculate gross earnings
- Solve income/expense problems
- Prepare a budget
- Calculate interest
- Solve interest problems
- Calculate sales tax
- Determine income tax
- Use calculator for computation
- Use computer for computation
- Use computer spreadsheets
- Apply computation skills as they are actually used on the job
- Calculate measurements taken from measuring devices
- Perform/prepare an inventory
- Calculate and compare shipping costs
- Prepare financial report

Science Skills

General Science

- Apply computing skills
- Apply scientific method of inquiry
- Conduct experiments
- Investigate science ethics
- Investigate science history
- Investigate/apply economics in technology
- Use scientific instruments
- Investigate/apply technology
- Collect specimens
- Construct model to depict basic concept of ----

Life Science

- Identify/classify living organisms
- Investigate biological history of the earth
- Investigate food chains, webs, pyramids
- Investigate/apply principles of human development
- Investigate/apply principles of genetics/heredity
- Investigate/apply principles of anatomy/physiology
- Investigate health issues
- Observe health code/sanitation requirements

Physical Science

- Analyze/classify matter
- Investigate forms/changes of matter
- Investigate forms/changes of energy
- Investigate/apply chemical properties
- Investigate/apply physical laws

Earth Science

- Investigate physical characteristics of the earth
- Investigate geological history of the earth
- Investigate physical forces acting on the earth
- Solve problems of longitude, latitude, and time zones
- Investigate conservation of physical resources
- Investigate conservation of living resources
- Investigate issues of environmental impact
- Apply science principles to environmental issues

Oral Communication Skills

Oral Presentation

- Make informative presentations
- Make persuasive presentations
- Present personal opinion/viewpoint
- Use good speaking techniques
- Select/use words effectively
- Use effective body language
- Present appropriate appearance
- Integrate audio and/or visual materials into oral presentations
- Adapt presentation to specific audience

Listening

- Apply active listening skills
- Distinguish fact, opinion, and inference
- Draw conclusions/make generalizations
- Analyze/identify point of view

Interactive Communication

- Give/follow oral directions
- Apply questioning techniques
- Conduct/receive interviews
- Analyze/apply nonverbal communication
- Work effectively in a group
- Communicate with clients/customers/patients
- Communicate with coworkers
- Communicate with supervisors
- Communicate with professional colleagues/associates
- Apply telephone etiquette

Interpersonal or Relating Skills

General Relating

- Investigate/apply communication process models
- Analyze/apply nonverbal communication
- Investigate/apply cross-cultural communication
- Interact with coworkers
- Interact with supervisors
- Interact with clients/customers/patients
- Interact with professional colleagues/associates
- Interact with family/friends
- Participate in group activities
- Participate in industrial relations/functions
- Identify personal values/attitudes
- Apply information to life experiences

Teamwork/ Cooperation

- Identify values/attitudes
- Identify needs/drives
- Select/apply appropriate behavior
- Investigate/identify personal styles
- Investigate/identify group/corporate climate
- Give/receive feedback
- Identify hidden purposes
- Investigate/apply group dynamics
- Control undesirable/inappropriate behavior
- Resolve conflicts
- Clarify goals/objectives
- Devise "win/win" situations
- Build consensus
- Generate ideas
- Present point of view

Leadership/ Influence

- Analyze/apply leadership styles
- Analyze/apply management styles
- Obtain confidence of others
- Develop esteem in self/others
- Persuade others
- Analyze/apply motivation techniques
- Provide positive coaching

Critical Thinking Skills

Cognitive Activities

- Collect/record information
- Identify critical elements/issues
- Define a problem
- Identify underlying causes
- Apply a problem-solving model
- Analyze/synthesize information
- Identify/analyze underlying assumptions
- Draw conclusions
- Predict results/outcomes
- Identify/evaluate consequences
- Identify/develop alternatives
- Evaluate alternatives
- Select an alternative
- Devise a solution
- Create a finished product
- Apply intuitive thinking techniques
- Transfer knowledge/training to new situations
- Apply new technology
- Develop an action plan
- Evaluate results/outcomes
- See relationship between two or more ideas, objects, or situations

Employability Skills

Job Search/ Selections

- Analyze personal occupational aptitudes/preferences
- Investigate employment prospects of a career field/occupation
- Investigate training requirements for a career field/occupation
- Investigate benefits of a career field/occupation
- Compare/evaluate career options
- Analyze impact of work on individual and family life

Job Acquisition/ Development

- Develop personal career path
- Locate appropriate jobs
- Analyze duties/requirements/benefits of specific job
- Master specific job task/procedure
- Complete job-related applications
- Write a letter of application
- Write personal resume
- Interview for a job
- Apply business etiquette
- Practice good work habits/attitudes
- Practice good personal presentation
- Develop self confidence/esteem
- Develop effective leadership
- Deal effectively with supervisors
- Deal effectively with coworkers
- Deal effectively with professional colleagues/associates
- Deal effectively with customers/clients/patients
- Follow established rules, regulations, and policies
- Promote the goals and values of the organization
- Exert a high level of effort and perseverance towards goal attainment
- Set high standards for self in completion of a task

Resource Management

- Complete task in timely manner
- Determine cost, time, and resources to complete a task
- Perform routine tasks related to equipment operation and/or maintenance

Job Safety

- Demonstrate safe use of tools, equipment, and supplies
- Observe safety rules
- Wear safety equipment
- Follow safety procedures
- Demonstrate proper use of safety device

Social Studies Skills

Information Analysis

- Collect/record data
- Interpret graphical information
- Construct graphical information
- Interpret maps/globes
- Interpret statistical information
- Analyze/interpret demographic information
- Distinguish trends and predicts impact of actions on systems operations

Social Studies Application

- Investigate/apply U.S. history
- Investigate/apply world history
- Investigate/apply U.S. geography
- Investigate/apply world geography
- Investigate/apply principles of government/politics
- Investigate/apply principles of economics
- Investigate/apply principles of ethics
- Investigate/apply principles of sociology
- Investigate/apply cross-cultural studies

Functional Social Studies

- Practice responsible personal economics
- Prepare a personal budget
- Use credit responsibly
- Practice good work ethics
- Participate in industrial relations
- Interact with people of different races/cultures
- Investigate/participate in government
- Investigate/apply American legal practices
- Select/use sources of information on current events
- Analyze current events
- Analyze consumer issues
- Analyze social issues
- Analyze conservation/ecology issues
- Analyze social impact of science/technology
- Analyze economic impact of science/technology
- Understand how social, organizational, and technological systems work and operate effectively

Technology Skills

Selection	• Choose procedures, tools, or equipment including computers and related technologies that will produce the desired results
Application	• Demonstrate the proper procedures for setting up and operating equipment, including computers and their programming systems
Maintenance/ Troubleshooting	• Perform maintenance on equipment, including computers and other technologies • Identify and correct problems with equipment • Report damaged or broken equipment to appropriate individual

Basic Skills Icons and Classifications

When an activity involving one of these basic skills is identified, the corresponding icon is placed in the left-hand margin of the assignment sheet or job sheet. Skills training is further defined by classifying specific skills that are required.

Example:

Unit 2 **General Safety and First Aid**

Objective 32

Assignment Sheet 1—Interpret a Material Safety Data Sheet

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Directions followed	_____
• All answers correct per Answers to Assignment Sheet 1	_____

Materials list • Pen or Pencil

Basic Skills Reading Writing Critical Thinking

Directions Review the material in Objective 4 of the information sheet, and locate and study the information presented in Student Supplement 2, "Guidelines for Interpreting Material Safety Data Sheets."

Use the MSDS at the end of this assignment sheet to answer the following questions. Write your answers on the blanks provided below each item.

MSDS Gel Graffiti®

a. What is this product used for?

____

b. What is the main ingredient in this product?

____

c. What does this product look like?

____

d. What percentage of this product is volatile (capable of exploding)?

____

MAVCC—*Basic Wiring* Page 2-53

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BASIC SKILLS MATRIX

	Reading	Writing	Mathematics	Science	Oral Communication	Interpersonal	Critical Thinking	Employability	Social Studies	Technology
Unit 1 Welding Orientation	X	X					X	X	X	
Unit 2 General Safety	X	X		X			X	X		
Unit 3 Welding Safety and First Aid	X	X		X			X			
Unit 4 Welding Tools and Equipment	X						X			
Unit 5 Basic Metals and Metallurgy	X			X			X	X	X	
Unit 6 Basic Math and Measuring	X		X					X		
Unit 7 Welding Print Reading	X	X		X			X			
Unit 8 Basic Welding Joints and Symbols	X	X					X			

Tools, Equipment, and Materials List

- Assorted electrodes
- Assorted structural shapes
- Basic hand tools
  - Adjustable wrench
  - Aligning pry bar
  - Allen wrench set
  - Assorted chisels
  - Assorted files
  - Assorted jacks
  - Assorted pliers
  - Assorted screwdrivers
  - Ball peen hammer
  - Bar clamps
  - Bolt cutter
  - Box-end wrench
  - C-clamps
  - Card file
  - Center punch
  - Chipping hammer
  - Clip plates or dogs
  - Cold chisel
  - Come-along
  - Cylinder wrench
  - Drift punch
  - Fitter's hammer
  - Flat bar
  - Hacksaw
  - Mallet
  - Open-end wrench
  - Pipe cutter
  - Pipe wrench
  - Plate dogs
  - Platen table and accessories
  - Prick punch
  - Sheet metal snips
  - Sledge hammer
  - Slings
  - Soapstone, sharpened
  - Socket wrench and handles
  - Spring clamps
  - Strongback
  - Torch wrench
  - Turnbuckles
  - Vise

Tools, Equipment, and Materials List

  - Vise-Grip® clamps
  - Wedges
  - Wire brushes
  - Yoke
- Cutting and Shaping Tools
  - Angle iron cutter, notcher, and bender
  - Anvil
  - Beverly shear
  - Hossfeld bender
  - Tap and die set
- Ladder, 12 foot
- Magnet
- Measuring tools
  - Bevel square
  - Calipers
  - Chalk line
  - Combination square
  - Drill point gauge
  - Framing square
  - Levels
  - Metal gauges
  - Micrometer
  - Plumb bob
  - Pocket tape
  - Rules
  - Steel tape
  - Wing dividers
- Oxyacetylene welding and cutting rig
- Power Equipment
  - Angle and straight grinders
  - Belt and disc sander
  - Cut-off saw
  - Drill press
  - Grinder, pedestal or portable
  - Hand drill
  - Heavy-duty hand drill
  - Manipulator
  - Pedestal buffer
  - Positioner
  - Power hacksaw
  - Power roll
  - Power shears
  - Press brake
  - Reciprocating saw
  - Turning rolls
  - Vertical band saw
- Safety Equipment
  - Assorted welding lenses
  - Face shield

- Fire extinguisher(s)
- Safety glasses
- Welding helmet
- Welding and cutting goggles
- Gloves with gauntlets
- Lower back support belt

Welding cables, hoses, and guns
- FCAW
- GMAW
- GTAW
- SMAW

Welding machines

Unit Contents

Teacher Components

Teacher Page

Suggested Activities 1–3
Answers to Assignment Sheets 1–9
Written Test 1–11
Answers to Written Test 1–17

Teacher Supplements

1—An Abbreviated History of Arc Welding 1–19
2—Professional Organizations That Benefit Welders 1–21

Transparency Masters

1—Master Chart of Welding and Allied Processes 1–23
2—Master Chart of Welding and Allied Processes (continued) 1–25

Student Components

Student Page

Learning Activities Sheet 1–3
Objective Sheet 1–5
Information Sheet 1–7

*Assignment Sheets

1—Identify Welding Processes 1
2—Compare Employment Opportunities in Welding 3

*Assignment Sheets are located in the Student Workbook.

Instructional Plan

Suggested Activities

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make copies of any teacher supplements that will be provided for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

  TM1—Master Chart of Welding and Allied Processes
  (Objectives 2, 3, and 4)
  TM2—Master Chart of Welding and Allied Processes (continued)
  (Objectives 2, 3, and 4)

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.

Suggested Activities

- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.

Teaching Suggestions

- Find a retired welder in your city or area and ask him or her to address the class about how welding has been as a career. Where was the job or where were the jobs? What were the working conditions? What was the pay? Were there company benefits? What made you want to become a welder? Did welding adversely affect your health? Would you pick welding as a career if you could do it all again?

  Note: Surveys indicate that some students think of welding as just another dirty job. Associating welding with the human aspect, the career approach, and placing it in an historical perspective may provide a very positive experience for many students.

- Discuss the major welding processes in detail and impress upon students the advantages of having multiple welding and cutting skills in the workplace. As some job areas decline, those welders with skills versatility will survive economic ups and downs.
- Talk to students about general opportunities in welding as they are outlined in this unit. Better yet, try to pinpoint special welding opportunities in your city, area, or state. Have welders from those industries talk to the class about the type of welding involved and how to plan for job opportunities.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.
- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.
- Give and evaluate the posttest.

- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- Connor, Leonard P., ed. *Welding Handbook Eighth Edition, Vol 1, Welding Technology*. Miami, FL: American Welding Society, 1987.
- O'Brien, R. L., ed. *Welding Handbook Eighth Edition, Vol. 2, Welding Processes*. Miami, FL: American Welding Society, 1991.
- *Occupation Outlook Handbook 1998-99, Bulletin 2500*. Washington, DC: U.S. Department of Labor, Bureau of Labor Statistics, 1998.

Suggested Supplemental Resources

Print Media

- Miller, R.T. *Welding Skills*, 2nd ed. Homewood, IL: American Technical Publishers, Inc., 1996.
- Jeffus, Larry. *Welding Principles and Applications*, 4th ed. Albany, NY: Delmar Publishers, Inc., 1998.
- The *Stabilizer®* is a magazine for people interested in welding and is published approximately every 8-10 months. Published by Lincoln Electric, the magazine has special features which recount welding projects by individual readers. "How I Did It" is a regular feature in the publication. For information, write, call, or visit their internet site.

  The Stabilizer
  The Lincoln Electric Company
  22801 St. Clair Avenue
  Cleveland, OH 44117
  216-481-8100
  www.lincolnelectric.com/stabilizer

- The *Welding Journal* is the official monthly publication of the American Welding Society. Monthly "Feature Articles" present in-depth coverage of significant welding information. For information, write, call, or visit their internet site.

  American Welding Society
  550 N.W. LeJeune Rd.
  Miami, FL 33126
  800-443-9353
  www.aws.org/wj/wj.htm

- *The American Welder*, a supplement to the *Welding Journal*, is a bi-monthly publication that provides information in such areas as the basics of welding, safety, education, events, and people. For information, write, call, or visit their internet site.

American Welding Society
550 N.W. LeJeune Rd.
Miami, FL 33126
800-443-9353
www.aws.org/wj/wj.htm

- *Welding Design and Fabrication* calls itself "The magazine of welding management and technology." Published by Penton Media, Inc., of Cleveland, Ohio, the magazine features articles of interest to industries that use welding processes in their activities. The magazine has feature articles on all facets of the industry, both domestic and international. For information, write, or visit their internet site.

Penton Media, Inc.
Welding Design and Fabrication
P.O. Box 901979
Cleveland, OH 44190-1979
www.penton.com

- *Design News*, as the name implies, is written for design engineers, but its frequent publication of articles related to metallurgy and welding, make it an important publication for companies active in welding fabrication. For information, write, call, or visit their internet site.

Design News
Marketing Services
1350 Touhy Avenue
Des Plaines, IL 60018
800-323-4958
www.manufacturing.net/magazine/dn

Electronic Media

- Welding: Making It Happen (23 Minutes)

  This video effectively portrays the many ways welding touches our everyday lives. An excellent choice for general presentations to parents, career counselors and vo-tech candidates.

- Welding as a Career (15 Minutes)

  Promoted are student opportunities in welding as a career and educational opportunities at a typical technical school. Portrayed are a range of welding career options and their benefits, such as possessing a productive skill, interesting work, good pay, and growth opportunities.

- Welding: So Hot, It's Cool (11 Minutes)

  The American Welding Society's career education video; provides students with information on career possibilities in welding. Designed for kids 13–15.

  Order the preceding videos online from the American Welding Society at www.aws.org, or call (800) 334-9353.

Answers to Assignment Sheets

Assignment Sheet 1

Identify Welding Processes

a. 3
b. 2
c. 4
d. 1
e. 7
f. 6
g. 5

Assignment Sheet 2

Compare Employment Opportunities in Welding

Should be evaluated to the evaluation criteria listed on Assignment Sheet 2.

Written Test

Name ______________________________

Date ______________________ Score __________

Objective 1

Define terms related to welding orientation. Write the correct definition beside the word.

a. Base metal: ______________________________

____

b. Coalescence: ______________________________

____

c. Fusion welding: ______________________________

____

____

d. Welding: ______________________________

____

____

Objective 2

Complete statements about welding processes by circling the information that best completes each of the following statements.

a. Oxyfuel Gas Welding (OFW)—A group of welding processes that produces coalescence by heating materials with an oxyfuel gas flame or flames, with or without pressure, and (**with**) (**with or without**) the use of filler material

b. Shielded Metal Arc Welding (SMAW)—An arc welding process that produces coalescence of materials by heating them with an arc between a covered electrode and a workpiece; shielding is obtained from decomposition of the electrode cover, pressure is not used, and filler metal is obtained from (**the electrode**) (**the electrode cover**)

c. Gas Tungsten Arc Welding (GTAW)—An arc welding process that produces coalescence of materials by heating them with an arc between a (**nonconsumable**) (**consumable**) tungsten electrode and a workpiece; shielding is obtained from a gas, and filler metal may or may not be used

d. Gas Metal Arc Welding (GMAW)—An arc welding process that produces coalescence of metals by heating them with an arc between a continuous filler metal electrode and a workpiece; shielding is obtained entirely from (**an externally supplied gas**) (**the reaction with the base metal**)

e. Flux-Cored Arc Welding (FCAW)—An arc welding process that produces coalescence of metals by heating them with an arc between a continuous filler metal electrode and a workpiece; shielding is provided by a flux contained within the tubular electrode, and additional shielding (**must**) (**may or may not**) be obtained from an externally supplied gas or gas mixture

f. Submerged Arc Welding (SAW)—An arc welding process that produces coalescence of metals by heating them with an arc or arcs between a bare metal electrode or electrodes and a workpiece; the arc and molten metal are shielded by (**chemical reactions**) (**a blanket of granular, fusible material**) on the workpiece; pressure is not used, and filler metal is obtained from the electrode or sometimes from a supplemental source

g. Plasma Arc Welding (PAW)—An arc welding process that produces coalescence of metals by heating them with a constricted arc between a (**nonconsumable**) (**consumable**) electrode and a workpiece (transferred arc), or the electrode and a constricting nozzle (nontransferred arc)

h. In PAW, shielding is obtained from the hot, ionized gas issuing from the torch, and this may be supplemented with an auxiliary source of shielding gas; shielding gas may be an inert gas or a mixture of gases, and filler metal (**must**) (**may or may not**) be used.

Objective 3

Select true statements about brazing and braze welding by placing an "X" in the blanks next to the true statements.

_____ a. Brazing is a group of welding processes that produces coalescence of materials by heating them to the brazing temperature in the presence of a filler metal having a melting point above 840°F and below the melting point of the base metal.

_____ b. In brazing processes, the filler metal is distributed between the closely fitted surfaces of the joint by capillary action.

_____ c. Braze welding is a welding process variation that uses a filler metal with a melting point above 840°F and above the melting point of the base metal.

_____ d. Like brazing, in braze welding, the filler metal is distributed in the joint by capillary action.

Objective 4

Complete statements about cutting processes by circling the correct answers.

a. Oxyfuel Gas Cutting (OFC)—A group of cutting processes used to sever metals by means of (**burning**) (**the chemical reaction of oxygen with a base metal**) at elevated temperatures; the necessary temperature is maintained by means of gas flames obtained from the combustion of a specified fuel gas and oxygen

b. Carbon Arc Cutting (CAC)—A group of cutting processes that sever or remove metal by (**melting**) (**chemical reaction**) with the heat of the arc between an electrode and the workpiece.

Objective 5

Select true statements about where welders work by placing an "X" in the blanks next to the true statements.

_____ a. In 1996, welders, cutters, and welding machine operators held over 500,000 jobs.

_____ b. About 9 out of 10 welders and cutters were employed in manufacturing, services, construction, or wholesale trade.

_____ c. The majority of those in manufacturing were employed in transportation equipment, industrial machinery and equipment, or fabricated metal products.

_____ d. All welding machine operators were employed in the automobile industry.

Objective 6

Complete statements about what welders earn by circling the information that best completes each of the following statements.

a. The median earning for welders and welding machine operators was about (**$478**) (**$600**) a week in 1996.

b. Beginners and lesser paid welders averaged $278 a week, but welders in the top 10 percent income bracket earned over (**$700**) (**$800**) a week.

c. Many welders work in situations where (**company benefits**) (**top wages**) make the job more attractive, and over one-fourth of all welders belong to a union.

Objective 7

Select true statements about the job outlook for welders by placing an "X" in the blanks next to the true statements.

_____ a. Employment of welders and cutters is expected to increase by 8.3% from 1998 through the year 2008.

_____ b. In some areas, the need for welders will rise through the year 2008, and many job openings will arise because of the need to replace experienced workers who transfer or retire.

_____ c. The areas that look best for good welding jobs are in construction and business services (repair) because these are areas that are difficult to automate.

_____ d. Many jobs will be open in manufacturing, but they will be jobs in maintenance, repair, and other areas where the work cannot be automated.

Objective 8

Complete statements about what it takes to become a good welder by circling the information that best completes each of the following statements.

a. Training for welding should start early in high school and include courses in shop math, mechanical drawing, print reading, physics, chemistry, and (**metallurgy**) (**electricity**).

b. Some welding machine operators can learn their jobs (**at special company classes**) (**in a few days or weeks**), but employers prefer applicants who have high school, vocational, and/or post-secondary training in welding.

c. Welders and cutters need manual dexterity, good eyesight, and good (**eye-hand coordination**) (**concentration**).

d. Good welders should also be able to concentrate on detailed work for long periods, and be able to bend, stoop, and (**work in awkward positions**) (**stand in one position a long time**).

Objective 9

Select career opportunities for welders. Circle the number of the information that best reflects each welder opportunity.

a. A maintenance shop is looking for someone who can perform many different welding jobs. Chances are they will hire:

(1) A combination welder
(2) A welder-fitter who can also work with pipe
(3) The welder who is good at GTAW

b. A firm that makes restaurant equipment and stainless steel salad bars needs a replacement welder. They will hire:

(1) A combination welder
(2) A specialist welder, probably a GTAW specialist
(3) A welder-fitter who is good with joint preparation

c. A company is looking for a welder to supervise a field crew that will be working on a special project. Chances are they will look for an experienced supervisor, but they could:

(1) Promote from within their own labor supply
(2) Select a welder who has demonstrated leadership abilities
(3) Look for a specialist welder

Written Test

Objective 10

Match to their definitions, the terms standard, code, and specification. Write the corresponding numbers on the blanks provided.

1. Standard 2. Code 3. Specification

_____ a. Generally associated with a process, uses the words *shall* and *will* to indicate the mandatory use of certain materials or actions, or both

_____ b. Describes the technical requirements for a material, process, product, system, or service

_____ c. Generally associated with a product, uses the words *shall* and *will* to indicate the mandatory use of certain materials or actions, or both

Objective 11

Complete statements about standards and their importance to the welding industry by circling the information that best completes each of the following statements.

a. In 1936, the Committee on Standard Qualification Procedures issued its first report to the American Welding Society; the report called for general qualification standards for (**procedures and performances**) (**the classification**) of welders.

b. Today, standards guide many industrial producers, and standards affecting welding are produced by other groups who have welding (**processes**) (**minimums**) that must be met and procedures that must be followed.

c. The American Welding Society has various committees who meet to update and change standards as needs require, and among these standards, three are important to all welders, including beginners:

(1) Standard for Welding (**Procedure**) (**Process**) and Performance Qualification
(2) Standards Symbols for Welding, (**Brazing**) (**Cutting**), and Nondestructive Examination
(3) Standard Welding (**Terms and Definitions**) (**Equipment**)

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. Base metal: The metal or alloy that is welded, brazed, soldered, or cut
b. Coalescence: The growing together or growth into one body of the materials being welded
c. Fusion welding: The melting together of filler metal and base metal, or of base metal only, to produce a weld
d. Welding: A joining process that produces coalescence of materials by heating them to a melting point, with or without the application of pressure and with or without the use of filler metal

Objective 2

a. With or without
b. The electrode
c. Nonconsumable
d. An externally supplied gas
e. May or may not
f. A blanket of granular, fusible material
g. Nonconsumable
h. May or may not

Objective 3

a, b

Objective 4

a. The chemical reaction of oxygen with a base metal
b. Melting

Objective 5

b, c

Objective 6

a. $478
b. $800
c. Company benefits

Objective 7

a, c, d

Objective 8

a. Metallurgy
b. In a few days or weeks
c. Eye-hand coordination
d. Work in awkward positions

Objective 9

a. 1
b. 2
c. 2

Objective 10

a. 2
b. 1
c. 3

Answers to Written Test

Objective 11

a. Procedures and performances
b. Minimums
c. (1) Procedure
    (2) Brazing
    (3) Terms and Definitions

Teacher Supplement 1—An Abbreviated History of Arc Welding

Early welding history

In Germany, metals were joined by electric fusion as early as 1782. English, French, and Russian experiments in the 1800s established the principles of striking and maintaining an electric arc with controlled voltage, and the first arc welding process resulted from ongoing efforts.

Early 1900 events

The first patent was issued for a covered electrode, and arc-welding methods were used to weld ship hulls and produce armaments during World War I.

Middle 1900 events

A new manufacturing process greatly reduced the cost of covered electrodes and arc welding applications expanded into the aircraft, manufacturing, and construction industries.

Later 1900 events

World War II inspired many advances in arc welding technology. Improvements in electrodes and improved applications of shielding gases brought high speed applications for the thousands of all-welded ships produced in World War II, in aircraft production, and in armaments.

Recent welding history

New arc welding processes such as GTAW and GMAW were developed to meet the special needs of industrial production and there were ongoing improvements and advances in electrode technology.

Modern welding history

Advances continued in electric arc welding and brought such processes as arc spot welding, atomic-hydrogen welding, electro-slag and electro-gas welding, plasma-arc welding and cutting, submerged arc welding, and other processes to answer special industry needs.

Teacher Supplement 2—Professional Organizations That Benefit Welders

Since welding is a metals and materials industry, the professional organizations that benefit welders do so by keeping pace not only with the world of welding, but changes, improvements, and trends in the many products associated with welders and welding. A few of those organizations are listed here for the purpose of providing references to assist with the variety of information that welding programs sometimes require.

Aluminum Association
900 19th Street, NW
Washington, DC 20006
202-862-5100
www.aluminum.org

American National Standards Institute
11 West 42nd Street, 13 Floor
New York, NY 10036
212-642-4900
www.ansi.org

American Society of Mechanical Engineers
Three Park Avenue
New York, NY 10016-5990
212-705-7722 — 800-843-2763
www.asme.org

National Safety Council
1121 Spring Lake Drive
Itasca, IL 60143-3201
630-285-1121
www.nsc.org

Society of Automotive Engineers
400 Commonwealth Drive
Warrendale, PA 15096-0001
724-776-4970
www.sae.org

American Iron and Steel Institute
1101 17th Street, NW, Suite 1300
Washington, DC 20036
202-452-7100
www.steel.org

American Petroleum Institute
1220 L Street, NW
Washington, DC 20005
202-682-8000
www.api.org

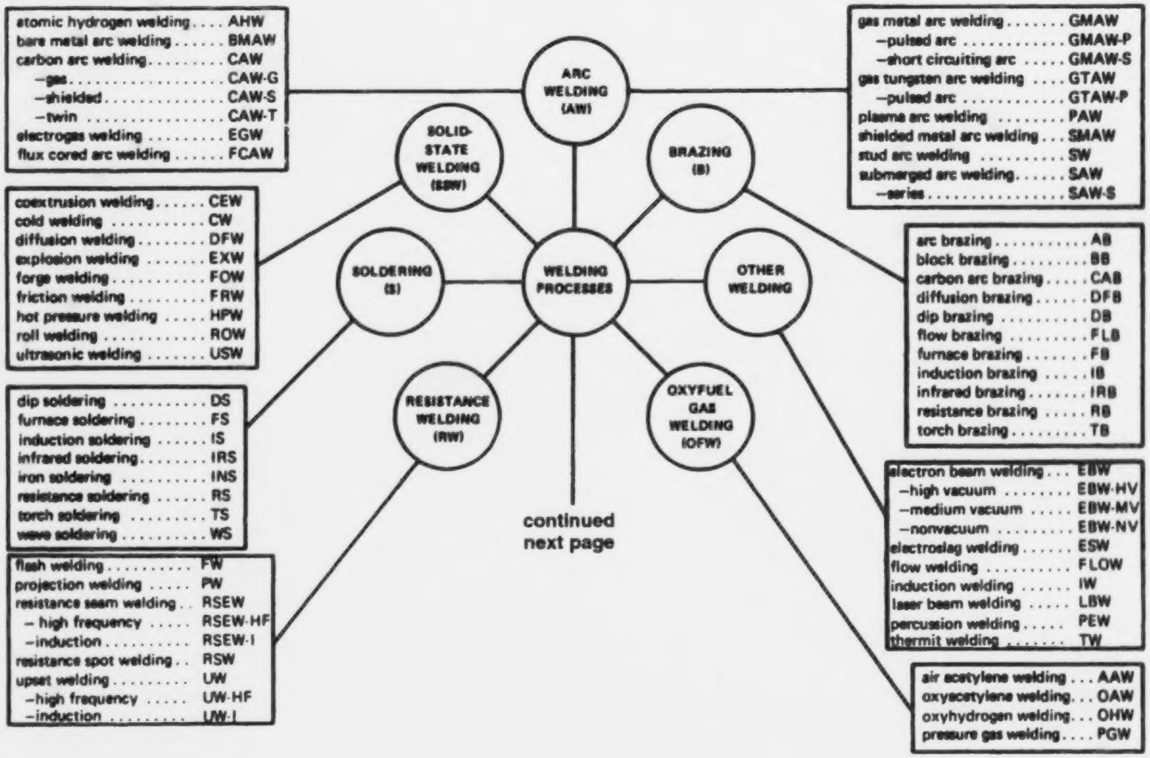
American Welding Society
550 N.W. LeJeune Rd.
Miami, FL 33126
800-443-9353
www.aws.org

National Welding Supply Association
1900 Arch Street
Philadelphia, PA 19103-1498
215-564-3484
www.nwsa.com

American Society of Non-Destructive Testing
4153 Arlingate Plaza, Caller #28518
Columbus, OH 43228-0518
www.asnt.org

•Permission to duplicate this supplement is granted.

Master Chart of Welding and Allied Processes



atomic hydrogen welding	AHW
bare metal arc welding	BMAW
carbon arc welding	CAW
—gas	CAW-G
—shielded	CAW-S
—twin	CAW-T
electrogas welding	EGW
flux cored arc welding	FCAW

gas metal arc welding	GMAW
—pulsed arc	GMAW-P
—short circuiting arc	GMAW-S
gas tungsten arc welding	GTAW
—pulsed arc	GTAW-P
plasma arc welding	PAW
shielded metal arc welding	SMAW
stud arc welding	SW
submerged arc welding	SAW
—series	SAW-S

coextrusion welding	CEW
cold welding	CW
diffusion welding	DFW
explosion welding	EXW
forge welding	FOW
friction welding	FRW
hot pressure welding	HPW
roll welding	ROW
ultrasonic welding	USW

arc brazing	AB
block brazing	BB
carbon arc brazing	CAB
diffusion brazing	DFB
dip brazing	DB
flow brazing	FLB
furnace brazing	FB
induction brazing	IB
infrared brazing	IRB
resistance brazing	RB
torch brazing	TB

dip soldering	DS
furnace soldering	FS
induction soldering	IS
infrared soldering	IRS
iron soldering	INS
resistance soldering	RS
torch soldering	TS
wave soldering	WS

electron beam welding	EBW
—high vacuum	EBW-HV
—medium vacuum	EBW-MV
—nonvacuum	EBW-NV
electroslag welding	ESW
flow welding	FLOW
induction welding	IW
laser beam welding	LBW
percussion welding	PEW
thermit welding	TW

flash welding	FW
projection welding	PW
resistance seam welding	RSEW
– high frequency	RSEW-HF
–induction	RSEW-I
resistance spot welding	RSW
upset welding	UW
–high frequency	UW-HF
–induction	UW-I

air acetylene welding	AAW
oxyacetylene welding	OAW
oxyhydrogen welding	OHW
pressure gas welding	PGW

continued next page

Courtesy American Welding Society

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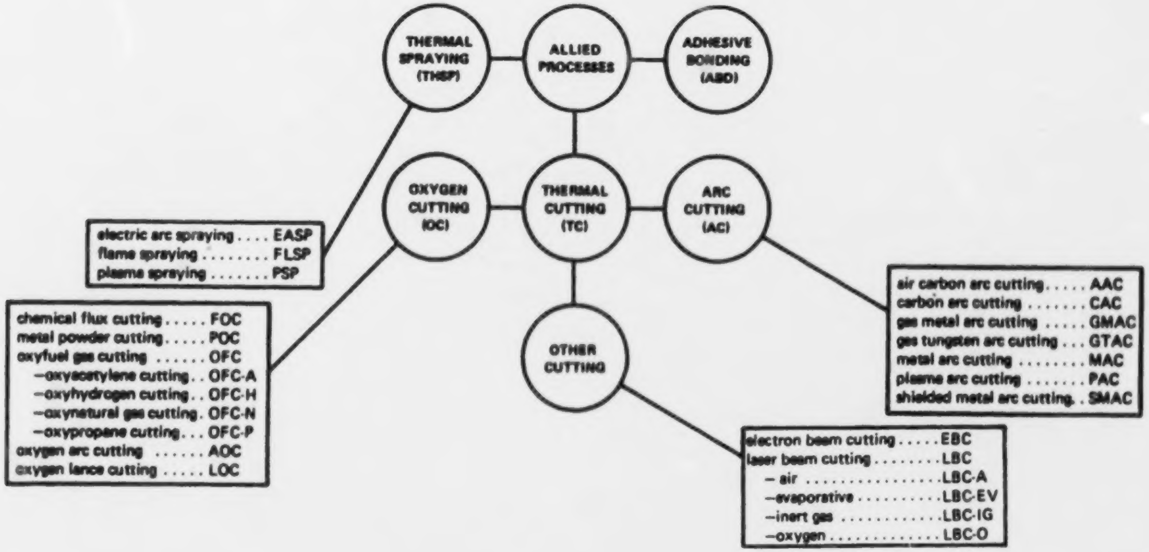
Master Chart of Welding and Allied Processes (continued)



ALLIED PROCESSES

THERMAL SPRAYING (THSP)

ADHESIVE BONDING (ABD)

THERMAL CUTTING (TC)

OXYGEN CUTTING (OC)

ARC CUTTING (AC)

OTHER CUTTING

electric arc spraying	EASP
flame spraying	FLSP
plasma spraying	PSP

chemical flux cutting	FOC
metal powder cutting	POC
oxyfuel gas cutting	OFC
—oxyacetylene cutting	OFC-A
—oxyhydrogen cutting	OFC-H
—oxynatural gas cutting	OFC-N
—oxypropane cutting	OFC-P
oxygen arc cutting	AOC
oxygen lance cutting	LOC

air carbon arc cutting	AAC
carbon arc cutting	CAC
gas metal arc cutting	GMAC
gas tungsten arc cutting	GTAC
metal arc cutting	MAC
plasma arc cutting	PAC
shielded metal arc cutting	SMAC

electron beam cutting	EBC
laser beam cutting	LBC
— air	LBC-A
—evaporative	LBC-EV
—inert gas	LBC-IG
—oxygen	LBC-O

Courtesy American Welding Society

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Unit 2 General Safety

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Unit Contents

*Assignment Sheets

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3—Draw a Layout of Your School and Apply the Safety Color Code ... 13
4—Determine Correct Fire Extinguishers to Use for Various Situations ... 15
5—Identify and Correct Safety Violations ... 17

*Job Sheets

1—Operate a Fire Extinguisher ... 19
2—Lift a Heavy Object Properly ... 21
3—Place and Climb a Ladder Safely ... 23

*Assignment and Job Sheets are located in the Student Workbook.

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make copies of any teacher supplements that will be provided for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

TM 1—Characteristics of a Hazardous Material (Objective 5)
TM 2—MSDS Example (Objective 6)
TM 3—Safety Tag Color Codes (Objective 8)
TM 4—The Fire Triangle (Objective 10)
TM 5—Types of Fire Extinguishers (Objective 12)
TM 6—Fire Extinguisher Markings (Objective 13)
TM 7—How to Lift Safely (Objective 16)
TM 8—How to Lift Safely (continued)
TM 9—Safety Practices for Step Ladders (Objective 18)
TM 10—Lockout/Tagout (Objective 19)

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Suggested Activities

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.
- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Break the unit up into smaller sets of objectives, and test students as they finish each set.
- Invite both students and parents to the school for a "parent night." While there, explain school and shop safety policies, and have parents and students sign the safety pledge.
- Obtain OSHA poster #2203, "Job Safety and Health Protection." Post it in the classroom prior to discussing objective 4.
- Have a local OSHA inspector talk to the class about OSHA rules and regulations.
- Invite a safety representative from local industry to talk to the class about safety practices and procedures.
- Show students examples of safety signs and tags.
- Have a local fire marshal or fire extinguisher company representative demonstrate the proper use of fire extinguishers.
- Discuss the fire evacuation plan for the classroom and shop, including evacuation routes and fire exits, as well as after-emergency evacuation routes and procedures for tornado alerts.
- Use objectives 15 and 16 to impress upon students that back problems constitute the most common claims in workers compensation cases. Try to obtain data from your state on workmen's compensation claims.
- Use Teacher Supplement 1, "Lockout/Tagout Procedures for Electrical Equipment" as supplemental lecture material, or as a student handout.

- Demonstrate the proper use of lockout/tagout procedures. Allow students to return your demonstration.

- Use Teacher Supplement 2, "Fall Protection Systems" as supplemental lecture material, or as a student handout.

- Use Teacher Supplement 3, "Employer/Employee Responsibilities Concerning Confined Space Entry" as supplemental lecture material, or as a student handout.

- Use Teacher Supplement 4, "Respirators" as supplemental lecture material, or as a student handout.

- Obtain a commonly used respirator and demonstrate its use to the class.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.

- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.

- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.

- Evaluate the job sheets.

  When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

  Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Suggested Activities

Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

Sample A

4—**Skilled**—Can perform job with no additional training.
3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
1—**Unskilled**—Is familiar with process, but is unable to perform job.
0—**No exposure**—No information or practice provided during training program.

Sample B

Yes—Can perform job with no additional training.
No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- Connor, Lenoard P., ed. *Welding Handbook, Eighth Edition, Vol. 1, Welding Technology.* Miami, FL: American Welding Society, 1987.
- National Fire Protection Association. *Fire Protection Handbook*, Fifteenth Edition. Quincy, MA: National Fire Protection Association, 1981.
- O'Brien, R. L., ed. *Welding Handbook, Eighth Edition, Vol. 2, Welding Processes.* Miami, FL: American Welding Society, 1991.
- *OSHA Safety and Health Standards (29 CFR 1910), Revised.* Washington, DC: U.S. Department of Labor, Occupational Safety and Health Administration, 1981.

Suggested Supplemental Resources

Print Media

- *The Welding Handbook, Eighth Edition, Vol. 1, Welding Technology* is a substantial source for welding safety information in a variety of categories. Vol. 2, *Welding Processes* also contains vital safety information. Both texts are highly recommended references that every welding program should have available for both reference and instruction. For information, call, write, or visit their internet site.

  Order Department
  America Welding Society
  550 Northwest LeJeune Road
  Miami, FL 33126
  800-334-9353
  www.aws.org

Electronic Media

Videotapes:

- Hazard Communications—Your Right to Know (18 Minutes)

  Required by OSHA for training employees who use chemicals/hazardous materials in the workplace. Describes material safety data sheets (MSDS), labeling, and basic safety when using these materials.

- Confined Space Entry (12 Minutes)

  This video address the risks and operational safety standards for confined spaces such as testing, ventilation, and rescue procedures.

- Back Injury Prevention–Safe Lifting (9 Minutes)

  The variety of lifting tasks in the manufacturing industry requires specific techniques under difficult conditions, and hazards resulting from incorrect methods. A must see for new workers.

- OSHA's Hazardous Energy Source–Lockout/Tagout (10 Minutes)

  A great training tool for "affected" and "authorized" employees in lockout/tagout procedures.

- HAZWOPER: Respiratory Protection (24 Minutes)

  Basic training requirements for selecting, wearing, using, storing, and handling respirators. Illustrates various types of respirators and how to use them. A demonstration on how to properly fit test respirators is included.

Suggested Activities

- Fire Extinguisher Training and Use 2000 (12 Minutes)

  This program explains the various classes of fires, different types of fire extinguishers, the word PASS, and other tips for emergency use of fire extinguishers.

- Ladder Safety (7 Minutes)

  Short program on the safe use of stepladders, straight ladders, platform ladders, and general safety measures needed to prevent potentially serious accidents.

- How to Prevent Slips, Trips, and Falls (13 Minutes)

  Covers potential hazards, importance of proper maintenance and cleaning procedures, and many other aspects of slips and falls.

- Fall Protection (21 Minutes)

  This video covers body harnesses, shock absorbing lanyards, swing effect, rope grabs, retractable lanyards, and more.

  Order the preceding videos online from MAVCC at www.mavcc.org, or call (800) 654-3988. Most videos are available in CD ROM format.

Internet:

- Occupational Safety and Health Administration (OSHA)
  www.osha.gov

Answers to Assignment Sheets

Assignment Sheet 1

Complete the Student Safety Pledge Form

Evaluated according to the criteria listed on the Assignment Sheet.

Assignment Sheet 2

Interpret a Material Safety Data Sheet—Gel Grafiti®

a. An engine degreaser
b. Ethanol
c. Opaque white gel
d. 77
e. Carbon dioxide and foam
f. Container may rupture
g. 50 ppm
h. Yes. Chlorinated hydrocarbon has produced cancer in animal studies
i. Inhalation
j. Headaches, dizziness, irritation, burning eyes, nausea, asphyxia, and possible chemical pneumonitis if aspirated into lungs
k. The victim should NOT be induced to vomit
l. Heat, sparks, welding arc, open flames
m. Strong oxidizing agents
n. Incinerate or landfill according to state, local, or federal regulations; should not be flushed to sewer
o. Safety glasses, neoprene gloves, and adequate ventilation
p. Wash with soap and water before handling food

Assignment Sheet 3

Draw a Layout of Your School Shop and Apply the Safety Color Code

Evaluated according to the criteria listed on the assignment sheet.

Assignment Sheet 4

Determine Correct Fire Extinguishers to Use for Various Situations

a. 1, 2
b. 2, 3
c. 2, 3
d. 2, 3
e. 2
f. 2, 3
g. 4
h. 2, 3
i. 2, 3
j. 2

Assignment Sheet 5

Identify and Correct Safety Violations

a. 1. Red warning tag was removed from drill
   2. Did not report stripped wire on drill to instructor
   3. Put drill with other tools
   4. Was going to try to fix drill cord with electrical tape
   5. Afternoon student did not check condition of drill before use
   6. Water on floor was ignored

b. 1. Margarita should have left red warning tag on drill.
   2-3. She should have reported the damaged tool to the instructor and it should have been removed from other tools until fixed.
   4. Repair of tools should be handled by instructor or under the instructor's supervision.
   5. Lamont should have checked the condition of the drill prior to plugging it in.
   6. The water spill should have been cleaned up. If water was still present, Lamont should have reported condition to the instructor and been assigned another job.

Written Test

Name ______________________________

Date ______________________________ Score______

Objective 1

Match the terms related to general safety below with their definitions. Definitions continue on next page.

1. Accident
2. Carelessness
3. Combustible
4. Flammable
5. Grounded
6. Guardrail systems
7. Hazard
8. Hazardous material
9. Heel
10. Hygiene
11. Lower levels

_____ a. A barrier erected to prevent employees from falling to lower levels

_____ b. Any cancer-causing, corrosive, toxic, irritant, sensitizer, or material that has, or has the potential for, damaging effects on specific body organs

_____ c. Failure to think before one acts; failure to pay attention

_____ d. Capable of being easily ignited and burning quickly at temperatures below 100° F

_____ e. Potential source of danger

_____ f. Suddenly occurring, unintentional event that causes injury or property damage

_____ g. To apply pressure to the bottom of a straight or extension ladder to prevent it from slipping or sliding sideways while in use

_____ h. Capable of bursting into flames at temperatures above 100° F

_____ i. Conditions or practices of cleanliness conducive to health

_____ j. Electrical connection to an object that conducts electrical current to the earth

_____ k. Those areas or surfaces to which an employee can fall. Such areas or surfaces include, but are not limited to, ground levels, floors, platforms, ramps, runways, excavations, pits, tanks, material, water, equipment, structures, or any portion of these

12. Material Safety Data Sheet
13. Occupational Safety and Health Act (OSHA)
14. Personal fall arrest system
15. Safety
16. Safety Net
17. Walking/working level

_____ l. Freedom from danger, risk, or injury

_____ m. A system used to arrest an employee in a fall from a working level. It consists of an anchorage, connectors, a body harness, and may include a lanyard, deceleration device, lifeline, or suitable combinations of these

_____ n. Any surface, whether horizontal or vertical, on which an employee walks or works, including, but not limited to, floors, roofs, ramps, bridges, scaffolds, and runways, but not including ladders, vehicles, or trailers, on which employees must be located in order to perform their job duties

_____ o. Form that lists and explains each of the hazardous materials that an employee works with so that the employee can safely use the material and respond to emergency situations

_____ p. Erected under a walking/working level when guardrail systems or personal fall arrest systems are not feasible

_____ q. Federal legislation designed to ensure safe and healthful working conditions for employees

Objective 2

Complete guidelines for dressing safely on the job. Write the correct words in the blanks.

a. Wear _______ _________________ appropriate for the activity being performed.

b. Wear _________________________ and _________________________ on all construction sites.

c. Always wear _______________________ when working.

d. Remove _______________________ and _______________________ jewelry when working with or near machine tools or rotating equipment.

e. Confine _______________________ before operating rotating equipment.

f. Remove _______________________ and _______________________ when working in the shop.

g. Wear protective _______________________ as appropriate.

h. Wear _______________________ in dusty areas.

i. Wear _______________________ when subjected to continuous loud noise.

j. Wear _______________________ when handling equipment and materials with sharp edges.

Written Test

Objective 3

Select true general job and shop safety rules by placing an "X" in the blanks next to the true statements.

Awareness and safe conduct

_____ a. Be alert for dangers and hazards

_____ b. Conduct yourself in a safe manner; participate in horseplay only on break periods.

_____ c. Do not work overtime in the shop unless another student is present.

_____ d. Consider the safety of others.

_____ e. Do not distract workers operating a tool or machine.

_____ f. Work with adequate light.

Fire safety

_____ a. Be familiar with the location of building exits and fire-fighting and first-aid equipment.

_____ b. Be aware of the voltage before plugging in a power tool.

Tool use, maintenance, and storage safety

_____ a. Use the right tool or equipment for the job, and use it properly.

_____ b. Keep all hand tools in an oil bath until needed.

_____ c. Retain all tool warranties and purchase orders.

_____ d. Operate a hazardous machine only after receiving instruction on how to operate the machine safely in all working conditions.

_____ e. Make sure that all guards and barriers are in place and adjusted properly before using a machine tool.

_____ f. Use correct, properly fitting drill bits for nuts, bolts, and objects to be turned or held.

_____ g. Keep work areas clean and free of debris and other hazards.

_____ h. Store tools, materials, and supplies safely in cabinets, on shelves, or other suitable areas.

_____ i. Keep sufficient brooms, brushes, and other housekeeping equipment readily available.

_____ j. Clean chips from a machine with a rag on your bare hands, not with a brush.

_____ k. Wear hand protection when using grinders and buffers.

Hazardous materials safety

_____ a. Use a solvent only after determining its properties, the kind of work it has to do, and how to use it.

_____ b. Use and store potentially hazardous materials and products strictly according to warranty instructions and cautions.

_____ c. Clean up any spilled liquids immediately.

_____ d. Store oily rags or oily waste in self-closing or spring-lid plastic containers.

Electrical safety

_____ a. Check all equipment before energizing or activating.

_____ b. Disconnect the power from energized tools, and tag or lockout machine tools, before performing any maintenance task such as oiling or cleaning.

_____ c. Do not run over electrical cords with dollies or carts.

_____ d. Tape down electrical cords that cross traffic lanes.

_____ e. Turn off the power before leaving a power tool or machine.

Objective 4

Complete statements concerning hazard communication by filling in the blanks with the correct answers.

a. OSHA established the Hazard Communication standard to protect the health and safety of ______________________.

b. This standard states that employees have both a need and a "_________ ______________ ______________" the hazards and the identities of the chemicals they are exposed to when working.

c. Employees also need to know what ____________ ______________ are available to prevent adverse effects from occurring.

d. OSHA requires employers to develop a written HazCom program including:

(1) Warning labels on containers

(2) ____________ ____________ ____________ ____________

(3) Employee training on the proper handling, usage, storage, and transportation of chemicals

Objective 5

Complete statements concerning the storage of hazardous materials by circling the word(s) that best completes each statement.

a. Select an area that meets local, state, and national (**opinions, codes**).

b. Store materials in (**metal cabinets, plastic baskets**).

c. Keep storage area (**locked, open**).

d. Store in open area (**near, away from**) open flame or excessive heat.

e. Always read (**text, labels**) for instructions on proper storage use.

Objective 6

Select words to complete facts about the purposes of material safety data sheets (MSDS). Write the correct numbers in the blanks at left.

_____ a. To inform _____ of the material's physical properties or fast-acting health effects that make it dangerous to handle.

1. OSHA
2. the management
3. the user
4. the health department

_____ b. To tell the user the level of _____ needed.

1. protective gear
2. medical care
3. hygiene
4. management

_____ c. To tell the user the _____ necessary if exposed to the product or its hazards.

1. preplanning
2. OSHA regulations
3. legal actions
4. first-aid treatment

_____ d. To tell management and the user the _____ needed for safely handling spills, fires, and day-to-day operations.

1. legal actions
2. preplanning
3. equipment and materials
4. personnel resources

_____ e. To tell the user how to _____ accidents.

1. report
2. respond to
3. prevent
4. record

Written Test

Objective 7

Match the colors of the safety color code with their uses. Write the correct number in the blanks.

1. Federal safety green
2. Federal safety white and black
3. Federal safety orange
4. Federal safety purple
5. Federal safety red
6. Federal safety yellow

_____ a. Designates caution and for marking physical hazards, waste containers for explosive or combustible materials; caution against starting, using, or moving equipment under repair; identification of the starting point or power source of machinery

_____ b. Identifies fire protection equipment and apparatus, portable container of flammable liquids, emergency stop bars, stop buttons, and emergency electrical stop switches on machinery

_____ c. Designates safety and the location of first aid equipment

_____ d. Designates dangerous parts of machines, safety starter buttons, parts of equipment that may produce electrical shock, and the exposed parts (edges only) of pulleys, gears, rollers, cutting devices, and power jaws

_____ e. Designates traffic flow; housekeeping zones

_____ f. Designates radiation hazards

Objective 8

Match illustrated safety tags with their color coding. Write the correct number in the blanks.

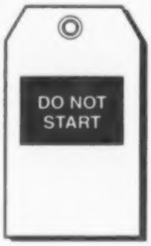
_____ a. White tag, white letters on red square

_____ b. White tag, white letters in red oval, on black square

_____ c. Yellow tag, yellow letters on black background

_____ d. Blue tag, white letters on black background

1.



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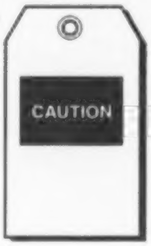

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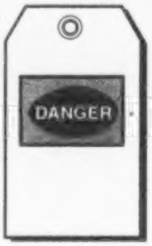

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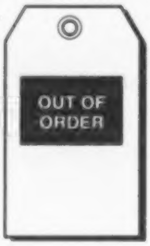


Objective 9

Match accident prevention signs with their colors and uses. Write the correct number in the blanks.

1. Caution signs
2. Danger signs
3. Safety instruction signs

_____ a. (1) Used where an immediate hazard exists

(2) Colors are red, black, and white

_____ b. (1) Used to warn against potential hazards or to caution against unsafe practices

(2) Colors are yellow and black

_____ c. (1) Used where there is a need for general instruction and suggestions relative to safety measures

(2) Colors are white, green, and black

Objective 10

List the components of the fire triangle.

a. ____

b. ____

c. ____

Objective 11

Match types of fires with their classifications. Write the correct numbers in the blanks.

1. Class A
2. Class B
3. Class C
4. Class D

_____ a. Fires that occur in electrical and electronic equipment

_____ b. Fires that occur in flammable liquids

_____ c. Fires that occur in ordinary combustible materials

_____ d. Fires that occur in combustible metals

Written Test

Objective 12

Match types of fires extinguishers with their uses. Write the correct numbers in the blanks.

1. Carbon dioxide
2. Halon
3. Dry powder
4. Dry chemical
5. Foam

______ a. Direct at base of flames; use for Class D fires.

______ b. Direct discharge as close to fire as possible, first at the edge of flames, then gradually forward and upward; use for Class B or Class C fires.

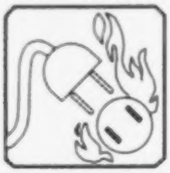
______ c. Instead of spraying stream into the burning liquid, allow substance to fall lightly on the fire; use for Class A or Class B fires.

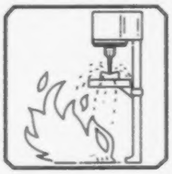
______ d. Direct at the base of the flames and follow up by directing at remaining material that is burning; use for Class B or Class C fires.

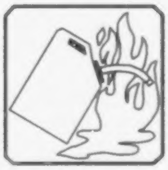
______ e. Direct at the base of fire, sweeping from side to side; use for Class C fires.

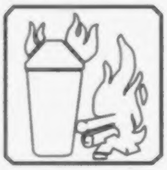
Objective 13

Identify the following fire extinguisher markings by stating which class of fire they correspond to.

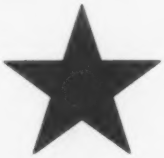




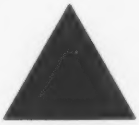




a. ______________ b. ______________ c. ______________ d. ______________



(Yellow star)



(Green triangle)

(Blue circle)

(Red square)

e. ______________ f. ______________ g. ______________ h. ______________

Objective 14

Complete fire extinguisher general operating instructions that follow the letters P-A-S-S

a. P ______________________________

b. A ______________________________

c. S ______________________________

d. S ______________________________

Objective 15

Match causes of back injuries with their contributing factors. Write the correct numbers in the blanks.

1. Improper storage
2. Weight
3. Obstructions
4. Improper reaching
5. Size
6. Shape
7. Improper position

____ a. Injury usually results from overestimating your physical abilities and trying to lift more weight than you can handle.

____ b. Injury usually results from moving an object that may be within your weight capacity, but is too long, high, or wide to lift safely.

____ c. Injury usually results from moving an object that may be within your weight capacity, but has a cylindrical or other odd shape that makes lifting difficult.

____ d. Injury usually results from stacking materials so high that vision is limited and obstructions in the pathways cannot be seen.

____ e. Injury usually results from twisting or turning to an awkward position when lifting.

____ f. Injury usually results in strain caused by not storing heavy objects at least 12 inches off the floor.

____ g. Injury usually results from carelessly using chairs or boxes instead of safely using a ladder, or by positioning/elevating an object too far from work.

Written Test

Objective 16

Select words to complete the guidelines for lifting and moving items safely. Write the correct numbers in the blanks at left.

Before lifting

_____ a. Inspect the item to be lifted for _____, and grease or other slippery surfaces.

1. wrapping, handholds
2. jagged edges, splinters
3. size, weight
4. obstacles, wrapping

_____ b. Wear _____ for protection, and make sure they fit correctly.

1. steel-toed shoes
2. safety goggles
3. ankle supports
4. gloves

_____ c. Wear _____ support.

1. abdominal
2. lower-back
3. neck
4. shoulder

_____ d. Plan your _____ before you lift.

1. strategy
2. tactics
3. route
4. position

_____ e. Clear any_____ from your path.

1. obstacles
2. guests
3. employees
4. floor coverings

_____ f. Assess the _____ of the load.

1. area
2. circumference
3. square footage
4. weight

_____ g. _____ to lift heavy loads.

1. Use your back
2. Get help
3. Call a professional
4. Use a pry bar

_____ h. Use a _____ to move very heavy, large, or awkward loads that cannot (or should not) be lifted by two people.

1. ramp
2. dolly
3. laundry cart
4. bus cart

Lifting

_____ i. Place your _____ as close to the load as possible.

1. head
2. shoulders
3. hip
4. feet

_____ j. Bend your knees, keeping your _____ straight and your chin tucked in.

1. leg muscles
2. arms and shoulders
3. back and neck
4. feet

_____ k. Grasp the load _____ with your fingers and hands.

1. loosely
2. at the top
3. at the bottom
4. firmly

_____ l. Draw your _____ in close to your body.

1. arms
2. knees
3. feet
4. buttocks

_____ m. Stand slowly and lift smoothly, using your _____.

1. legs
2. shoulders
3. back
4. knees

Carrying

_____ n. Hold the item _____.

1. at least 1 foot from waist
2. at knee level
3. at shoulder level
4. close to your body

_____ o. Do not allow the load to _____.

1. touch your chest
2. rest on your shoulder
3. block your vision
4. shift toward your body

_____ p. Do not _____ or twist your body to change direction.

1. set the load down
2. turn your head
3. change your grip
4. adjust your footing

Setting the load down

_____ q. Bend your _____.

1. arms
2. knees
3. back
4. head

_____ r. Keep your _____ straight and aligned.

1. back and neck
2. knees and legs
3. arms and elbows
4. chin and head

_____ s. Place the load carefully on the floor or shelf, taking care not to set it _____.

1. on your fingers or feet
2. on an even surface
3. toward the back of the receiving surface
4. squarely on the receiving surface

Objective 17

List five guidelines for preventing slips, trips, and falls.

a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____________________

Objective 18

Select words to complete rules for using ladders safely. Write the correct numbers in the blanks at left.

_____ a. Make sure that the ladder has non-skid safety _____.

1. hooks
2. shoes
3. rungs
4. beams

_____ b. Inspect the ladder before use for worn safety shoes, broken or loose _____ or other defects.

1. paint
2. screws
3. rungs/steps
4. truss blocks

_____ c. Inspect the ladder rungs/steps and siderails for _____ before you climb.

1. chipped or worn paint
2. oil or other slippery materials
3. levelness and construction
4. non-skid surfaces and dirt

_____ d. Be sure that ladders—particularly _____ ladders—are clear of electrical hazards.

1. metal
2. wood
3. fiberglass
4. composition

_____ e. Locate the ladder away from doors or other openings that are not _____.

1. open
2. closed
3. outswinging
4. blocked or guarded

_____ f. Place the ladder feet on a _____, non-skid surface.

1. perpendicular
2. level
3. smooth
4. vertical

_____ g. Place the ladder at a safe angle to the work: at least _____ from the wall for each _____ of height.

1. 4 feet; 1 foot
2. 2 feet; 10 feet
3. 1 foot; 4 feet
4. 8 inches; 3 feet

_____ h. Use _____ to secure sections of extension ladders.

1. rung locks
2. a screwdriver
3. properly knotted rope
4. vise-grip pliers

_____ i. Place the top of extension and straight ladders at least _____ rungs above the work.

1. one
2. two
3. three
4. four

_____ j. Get a helper to _____ straight or extension ladders.

1. toe
2. foot
3. heel
4. boot

_____ k. _____ the ladder when climbing up and down.

1. Face
2. Keep your back to
3. Skip rungs of
4. Hug

_____ l. Never stand on the _____ rung/step.

1. lowest
2. top
3. center of the
4. edges of the

_____ m. Do not _____ while on the ladder; descend the ladder and reposition it instead.

1. overextend your reach
2. reach above your head
3. work to the right
4. work to the left

_____ n. Allow only _____ on the ladder at a time.

1. four persons
2. three persons
3. two persons
4. one person

_____ o. Do not use ladders for_____.

1. cleaning windows
2. makeshift scaffolds
3. emergency exits
4. cleaning electrical fixtures

_____ p. Store ladders _____ when not in use.

1. securely
2. off the ground
3. in vertical position
4. on their sides

Objective 19

List instances when lockout devices should be used.

a. ____

b. ____

c. ____

d. ____

Written Test

Objective 20

List three types of fall protection systems.

a. ____________________

b. ____________________

c. ____________________

Objective 21

Match the terms related to confined space entry below with their correct characteristics. Some terms may have multiple characteristics. Write the correct numbers in the blanks.

1. Confined Space
2. Non-Permit Confined Space
3. Permit Required Confined Space
4. Permit Required Confined Space Program

_____ a. Contains a material for engulfing an entrant

_____ b. Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor that slopes downward and tapers to a smaller cross-section

_____ c. Large enough or so configured that an employee can bodily enter and perform assigned work

_____ d. Controls and protects employees from permit space hazards and regulates employee entry into permit spaces

_____ e. Is not designed for continuous employee occupancy

_____ f. Contains a recognized serious safety or health hazard

_____ g. Has limited or restricted means for entry or exit

_____ h. A confined space that does not contain or, with respect to atmospheric hazards, have the potential to contain any hazard capable of causing death or serious physical harm

_____ i. Contains or has potential to contain a hazardous atmosphere

Objective 22

List 8 environmental contaminants that would require you to use a respirator.

a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____

f. ____

g. ____

h. ____

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 6
b. 8
c. 2
d. 4
e. 7
f. 1
g. 9
h. 3
i. 10
j. 5
k. 11
l. 15
m. 14
n. 17
o. 12
p. 16
q. 13

Objective 2

a. Clothing
b. Hard hats, safety shoes
c. Safety glasses
d. Ties, dangling jewelry
e. Long hair
f. Rings, other jewelry
g. Clothing
h. Dust masks
i. Hearing protection
j. Gloves

Objective 3

Awareness and safe conduct—a, d, e, f
Fire safety—a
Tool use, maintenance, and storage safety—a, d, e, g, h, i
Hazardous materials safety—a, c
Electrical safety—a, b, c, e

Objective 4

a. Employees (workers)
b. Right To Know
c. Protective measures
d. Material Safety Data Sheets (MSDS)

Objective 5

a. Codes
b. Metal cabinets
c. Locked
d. Away from
e. Labels

Objective 6

a. 3
b. 1
c. 4
d. 2
e. 2

Objective 7

a. 6
b. 5
c. 1
d. 3
e. 2
f. 4

Answers to Written Test

Objective 8

a. 1
b. 3
c. 2
d. 4

Objective 9

a. 2
b. 1
c. 3

Objective 10

Answers may be given in any order

a. Fuel
b. Heat
c. Oxygen

Objective 11

a. 3
b. 2
c. 1
d. 4

Objective 12

a. 3
b. 1
c. 5
d. 4
e. 2

Objective 13

a. Class C
b. Class D
c. Class B
d. Class A
e. Class D
f. Class A
g. Class C
h. Class B

Objective 14

a. **P**ull pin.
b. **A**im nozzle toward fire.
c. **S**queeze handle.
d. **S**weep nozzle back and forth at base of flames.

Objective 15

a. 2
b. 5
c. 6
d. 3
e. 7
f. 1
g. 4

Objective 16

a. 2
b. 4
c. 2
d. 3
e. 1
f. 4
g. 2
h. 2
i. 4
j. 3
k. 4
l. 1
m. 1
n. 4
o. 3
p. 3
q. 2
r. 1
s. 1

Answers to Written Test

Objective 17

Answer should include any five of the following:

a. Wipe up spills immediately.
b. Post warning signs when floors are wet.
c. Use handrails on stairs.
d. Report any tripping hazard.
e. Do not leave equipment, materials, or other obstacles in hallways, on stairs or landings, before doors and exits, or in any other area where people may trip over them.
f. Do not stretch extension cords across traffic areas.
g. Use a ladder instead of a chair or box to reach high objects or areas.

Objective 18

a. 2
b. 3
c. 2
d. 1
e. 4
f. 2
g. 3
h. 1
i. 3
j. 3
k. 1
l. 2
m. 1
n. 4
o. 2
p. 1

Objective 19

a. Use when more than one power source is present.
b. Always use when hydraulic position could change.
c. Always use when pneumatic position could change.
d. Use to lock off all electrical devices before working on equipment.

Objective 20

Answers may be given in any order.

a. Guardrail systems
b. Safety nets
c. Personal fall arrest systems

Objective 21

a. 3
b. 3
c. 1
d. 4
e. 1
f. 3
g. 1
h. 2
i. 3

Objective 22

Answers may be given in any order.

a. harmful dusts
b. fogs
c. fumes
d. mists
e. gases
f. smokes
g. sprays
h. vapors

Teacher Supplement 1—Lockout/Tagout Procedures for Electrical Equipment

Lockout/Tagout procedures are used to prevent electric shock or other injuries resulting from either direct or indirect contact with fixed electrical equipment, when:

a. Working on or near equipment or circuits which are, or may be energized

b. Required to remove or bypass a guard or other safety device

c. Required to place any part of your body into an area on a machine or piece of equipment, where work is actually performed upon the material being processed

Note: Fixed equipment is equipment fastened in place or connected by hard wiring methods. Lockout/tagout does not apply to cord and plug connected equipment, if the equipment can be "unplugged' and the plug is under the exclusive control of the person performing the work.

"Live" parts shall be deenergized before the employee works on or near them, unless the employer can demonstrate that deenergizing introduces increased hazards or is infeasible due to equipment design or operational limitations. Live parts that operate at less than 50 volts to ground, need not be deenergized if there will be no increased exposure to electrical burns or to explosion due to electric arcs.

Procedures for deenergizing equipment:

a. Disconnect the circuits and equipment from all electric energy sources.

Note: Control circuit devices, such as push buttons, selector switches, and interlocks, may not be used as the sole means for deenergizing circuits or equipment. Interlocks for electric equipment may not be used as a substitute for lockout and tagging procedures.

b. Release stored electric energy if it might endanger life.

c. If stored non-electric energy could reenergize electric circuit parts, they shall be blocked or relieved so that the device could not accidentally energize the circuit parts.

If an employee is exposed to parts of fixed electrical equipment or circuits which have been deenergized, the circuits energizing the parts shall be locked out or tagged, or both.

A lock and tag shall be placed on each disconnecting means used to deeenergize circuits and equipment on which work is to be performed.

a. The lock shall be attached so as to prevent persons from operating the disconnecting means unless they resort to undue force or the use of tools.

b. Each tag shall contain a statement prohibiting unauthorized operation of the disconnecting means and removal of the tag.

Teacher Supplement 1

A tag may be used without a lock if the employer can demonstrate that tagging procedures will provide a level of safety equivalent to that obtained by the use of a lock and:

a. The tag is supplemented by at least one additional safety measure that provides a level of safety equivalent to that obtained by use of a lock. Examples of additional safety measures include the removal of an isolating circuit element, blocking of a controlling switch, or opening of an extra disconnecting device.

A lock may be placed without a tag only under the following conditions:

a. Only one circuit or piece of equipment is deenergized and

b. The lockout period does not extend beyond the work shift, and

c. Employees exposed to the hazards associated with reenergizing the circuit or equipment are familiar with this procedure.

Each lock and tag shall be removed by the employee who applied it or under his or her direct supervision. However, if this employee is absent from the workplace, then the lock or tag may be removed by a qualified person designated to perform this task.

Teacher Supplement 2—Fall Protection Systems

Note: It's the reponsibility of the employer to determine if the walking/working surfaces on which its employees are to work have the strength and structural integrity to support employees safely.

1. Each employee on a walking/working surface with an unprotected edge which is 6 feet or more above a lower level, shall be protected from falling by the use of guardrail systems, safety net systems or personal fall arrest systems.

   a. **Guardrail Systems**

   - Used primarily on scaffolding, around holes, and on ramps and runways
   - Top edge height of a guardrail shall be 42 inches plus or minus 3 inches above the walking/working level

   b. **Safety Net**

   - Shall be installed as close as practical under the walking/working surface on which employees are working, but in no case more than 30 feet below that level
   - Shall be inspected at least once a week for wear, damage, and other deterioration
   - Materials, scrap pieces, equipment, and tools which have fallen into the safety net shall be removed as soon as possible from the net and at least before the next work shift

   c. **Personal Fall Arrest System**

   Caution: Effective January 1, 1998, body belts are not acceptable as part of a personal fall arrest system.

   - Attachment point of the body harness shall be located in the center of the wearer's back near shoulder level, or above the wearer's head
   - Shall be inspected prior to each use for wear, damage and other deterioration, and defective components shall be removed from service
   - Shall not be attached to guardrail systems nor hoists
   - Anchorages used for attachment of personal fall arrest equipment shall be independent of any anchorage being used to support or suspend platforms and capable of supporting at least 5,000 lbs. per employee attached.
   - Shall be rigged so that an employee can neither free fall more than 6 feet nor contact any lower level

   Note: The employer shall provide for prompt rescue of employees in the event of a fall or shall assure that employees are able to rescue themselves.

2. Definition of Terms

   a. **Anchorage**—A secure point of attachment for lifelines or lanyards

   b. **Body Belt (safety belt)**—A strap with means both for securing it about the waist and for attaching it to lanyard, lifeline, or deceleration device

   c. **Body Harness**—Straps which may be secured about the employee in a manner that will distribute the fall arrest forces over at least the thighs, pelvis, waist, chest and shoulders with means for attaching it to other components of a personal fall arrest system

   d. **Connector**—A device which is used to couple (connect) parts of the personal fall arrest system

   e. **Guardrail Systems**—A barrier erected to prevent employees from falling to lower levels

   f. **Hole**—A gap or void 2 inches or more in dimension, in a floor, roof, or other walking/working surface

   g. **Lanyard**—A flexible line of rope or strap which generally has a connector at each end for connecting the body harness to a deceleration device, lifeline, or anchorage

   h. **Lifeline**—A component consisting of a flexible line for connection to an anchorage at one end to hang vertically, or at both ends to hang horizontally

   i. **Lower Levels**—Those areas or surfaces to which an employee can fall. Such areas or surfaces include, but are not limited to, ground levels, floors, platforms, ramps, runways, excavations, pits, tanks, material, water, equipment, structures, or a portion of these

   j. **Personal Fall Arrest System**—A system used to arrest an employee in a fall from a working level. It consists of an anchorage, connectors, a body harness, and may include a lanyard, deceleration device, lifeline, or suitable combinations of these.

   k. **Safety Net**—A net erected under a walking/working level when guardrail systems or personal fall arrest systems are not feasible

   l. **Walking/Working Level**—Any surface, whether horizontal or vertical, on which an employee walks or works, including, but not limited to, floors, roofs, ramps, bridges, scaffolds, and runways, but not including ladders, vehicles, or trailers, on which employees must be located in order to perform their job duties

Teacher Supplement 3—Employer/Employee Responsibilities Concerning Confined Space Entry

a. Employer responsibilities

- Determine whether confined spaces require a permit to enter.
- If the workplace contains permit spaces, the employer shall inform exposed employees, by posting danger signs or by any other equally effective means, of the existence and location of, and the danger posed by the permit spaces.

  Note: A sign reading "DANGER–PERMIT-REQUIRED CONFINED SPACE, DO NOT ENTER" or using other similar language would satisfy the requirement for a sign.
- If your employer decides that its employees will enter permit spaces, the employer shall develop and implement a written permit space program.
- Provide all equipment necessary to allow the employee to complete the job safely.
- Provide training so that all employees who may enter confined spaces acquire the understanding, knowledge, and skills necessary for the safe performance of duties.

b. Employee responsibilities

- Never enter any confined space without first finding out whether it requires a permit.
- If entry does require a permit, thoroughly read all instructions before entering and ensure the permit is posted at the entry portal so you can confirm that pre-entry preparations have been completed.
- Know the hazards that may be faced during entry, including information on the mode, signs or symptoms, and consequences of the exposure.
- Never enter a permit-required confined space without an attendant present, and always maintain constant communication with the attendant.
- Alert the attendant whenever you detect a prohibited condition.
- Properly use provided equipment.

Teacher Supplement 4—Respirators

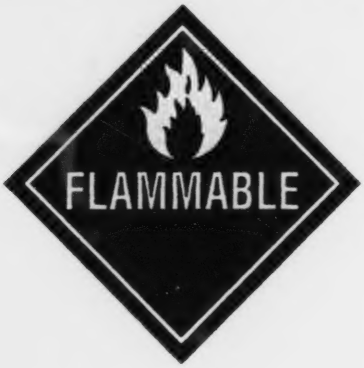
Note: Before considering respirator use, the primary objective shall be to control occupational diseases caused by breathing air contaminated with harmful dusts, fogs, fumes, mists, gases, smokes, sprays, or vapors. This will be accomplished by engineering measures (for example, enclosure or confinement of the operation, general and local ventilation, and substitution of less toxic materials). If this isn't possible, or while the procedures are being completed, appropriate respirators shall be used.

1. Persons should not be assigned to tasks requiring use of respirators unless it has been determined that they are physically able to perform the work and use the equipment. The local physician shall determine what health and physical conditions are pertinent. The respirator user's medical status should be reviewed periodically (for instance, annually).
2. Respirator selection is based on:
    a. The chemical and physical properties of the contaminant, as well as how toxic (deadly) it is, and how much there is of it.
    b. What the hazard is, the work requirements and condition, and the limitation and characteristics of the available respirators
3. Respirators shall be approved by the Mine Safety and Health Administration and the National Institute for Occupational Safety, or acceptable to the U.S. Department of Labor for the specific contaminant to which the employee is exposed.
4. The employer shall provide respirators when necessary to protect the health of an employee, and be responsible for the establishment and maintenance of a respiratory protective program that includes:
    a. Selecting the proper respirator
    b. Training the employee in the proper use of the selected respirator
    c. Providing a storage area
    d. Establishing a periodic inspection and cleaning program
    e. Establishing written procedures covering safe use of respirators in dangerous atmospheres that might be encountered in normal operations or emergencies
5. OSHA Standard 29 CFR–1926.103 lists the types of respirators required for protection in dangerous atmospheres. (www.osha.gov)

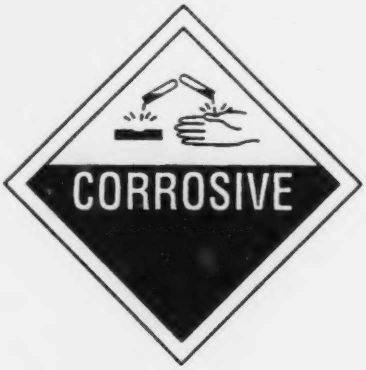
Caution: In areas where the wearer, with failure of the respirator, could be overcome by a toxic or oxygen-deficient atmosphere, at least one additional man shall be present. Communications (visual, voice, or signal line) shall be maintained between both or all individuals present. Rescue equipment must be available.

Characteristics of a Hazardous Material

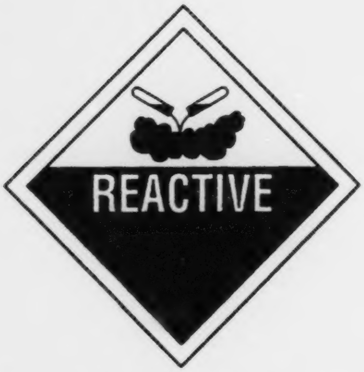
*If the MSDS or chemical label lists any of these characteristics, then the material is considered hazardous.



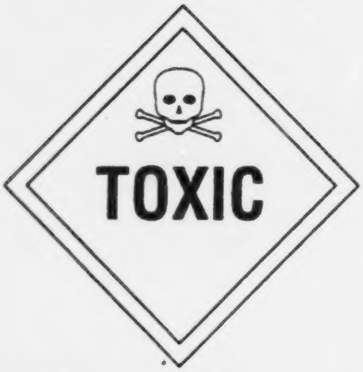
Capable of being easily ignited and burning quickly at temperatures below 100°F; can explode



Capable of dissolving metals and/or burning skin and eyes

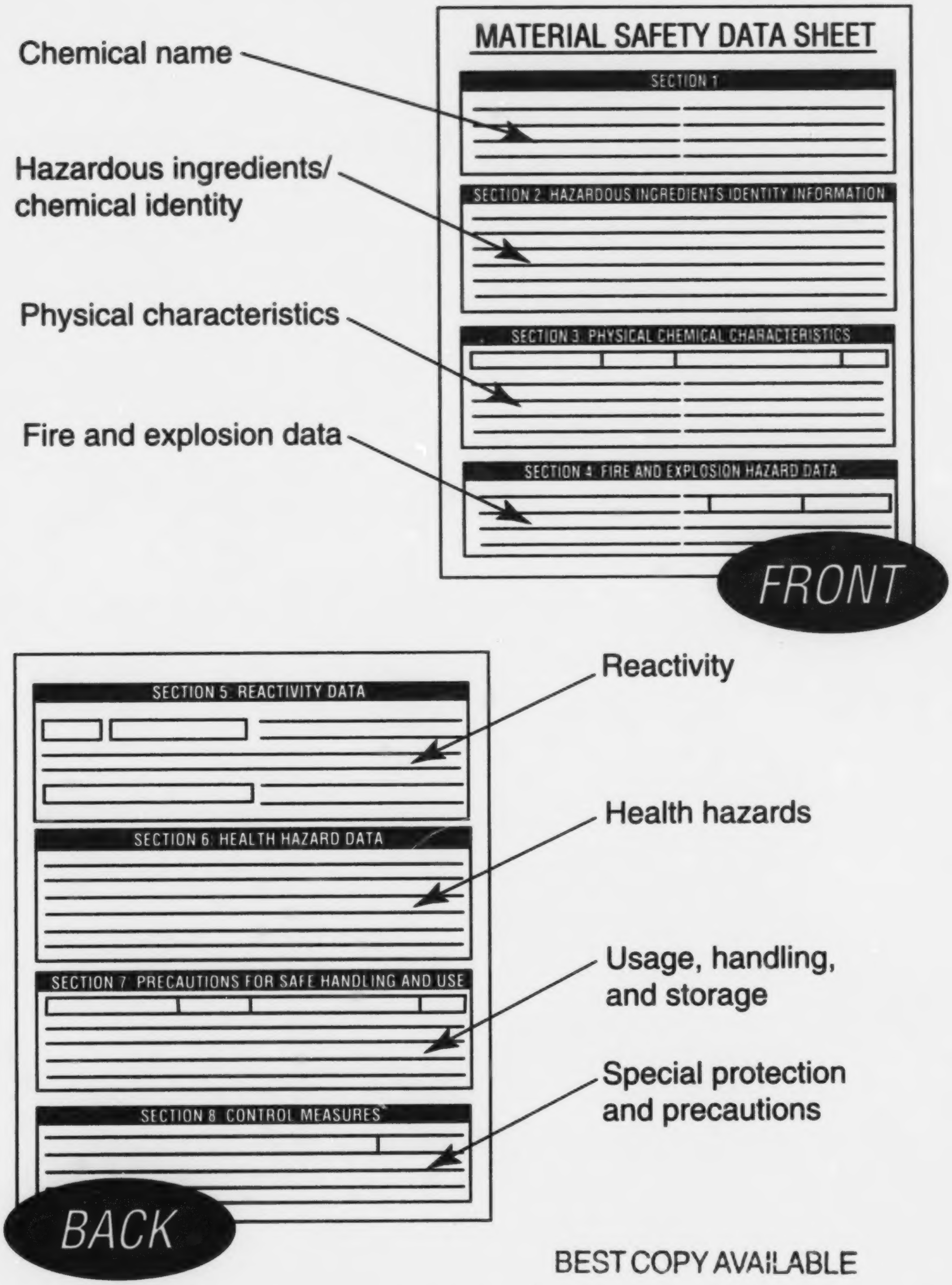


Capable of burning, exploding, or giving off harmful vapors if mixed with air, water, heat, or other materials



Capable of causing illness or death after exposure, even at very low levels

MSDS Example


MATERIAL SAFETY DATA SHEET
SECTION 1
SECTION 2 HAZARDOUS INGREDIENTS IDENTITY INFORMATION
SECTION 3 PHYSICAL CHEMICAL CHARACTERISTICS
SECTION 4 FIRE AND EXPLOSION HAZARD DATA
FRONT
SECTION 5 REACTIVITY DATA
SECTION 6 HEALTH HAZARD DATA
SECTION 7 PRECAUTIONS FOR SAFE HANDLING AND USE
SECTION 8 CONTROL MEASURES
BACK

Chemical name

Hazardous ingredients/ chemical identity

Physical characteristics

Fire and explosion data

Reactivity

Health hazards

Usage, handling, and storage

Special protection and precautions

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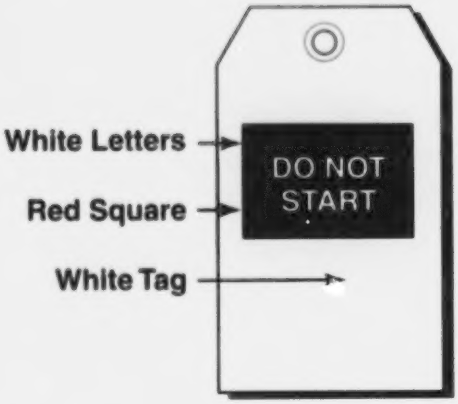
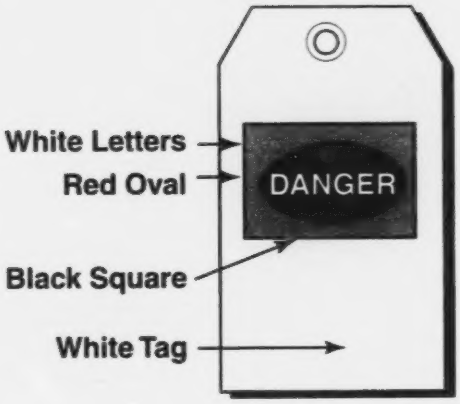
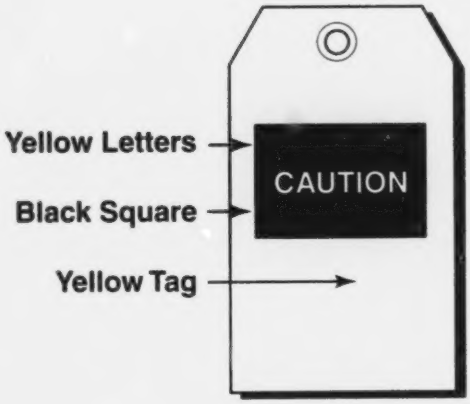
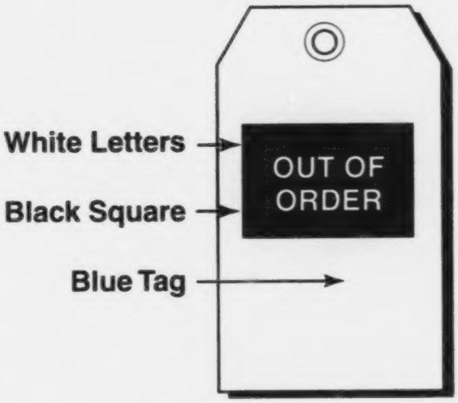
Safety Tag Color Codes


White Letters
Red Square
White Tag
DO NOT START


White Letters
Red Oval
Black Square
White Tag
DANGER

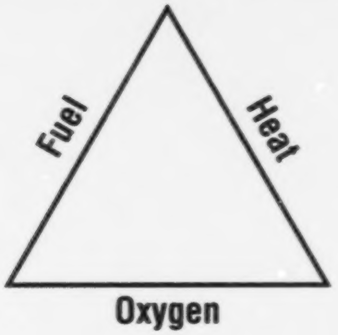

Yellow Letters
Black Square
Yellow Tag
CAUTION


White Letters
Black Square
Blue Tag
OUT OF ORDER

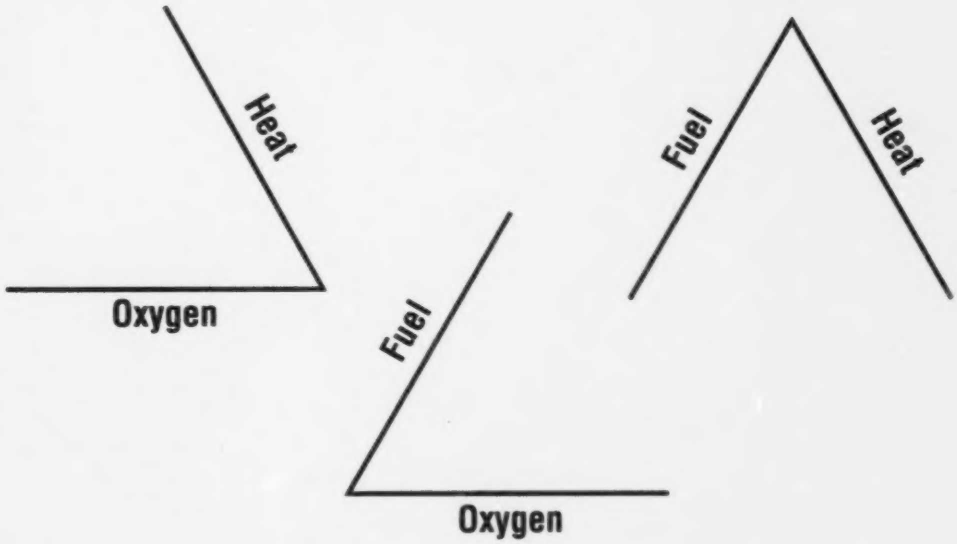
TM 3

The Fire Triangle

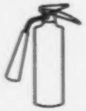
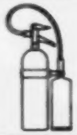
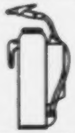
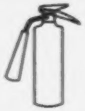
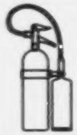
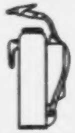
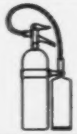
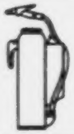
- To produce fire, three things must be present at the same time


Fuel
Heat
Oxygen

- If any one of the three is missing, a fire cannot be started.
- If any one of the three is removed from a fire, the fire will be extinguished.


Heat
Oxygen
Fuel
Oxygen
Fuel
Heat

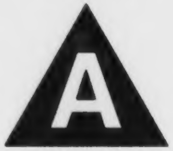
Types of Fire Extinguishers

Type of Fire	Approved Type of Extinguisher				
	Dry Powder	Carbon Dioxide	Multi-Purpose Dry Chemical	Halon Gas	Foam
Class A Fires **ORDINARY COMBUSTIBLES** • Wood • Paper • Cloth, etc.					
Class B Fires **FLAMMABLE LIQUIDS, GREASE** • Gasoline • Paints • Oils, etc.					
Class C Fires **ELECTRICAL EQUIPMENT** • Motors • Switches, etc.					
Class D Fires **COMBUSTIBLE METALS** • Magnesium • Phosphorus • Iron					

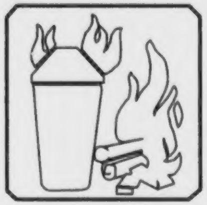
Fire Extinguisher Markings

Class A

(Green)

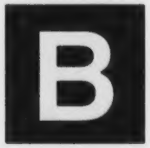


- Ordinary combustibles

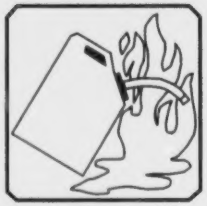


Class B

(Red)

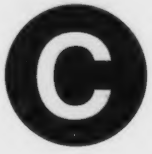


- Flammable liquids and gases

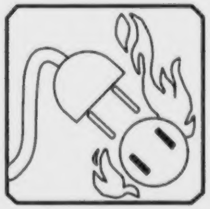


Class C

(Blue)

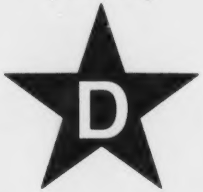


- Live electrical equipment

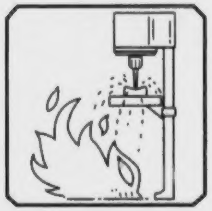


Class D

(Yellow)



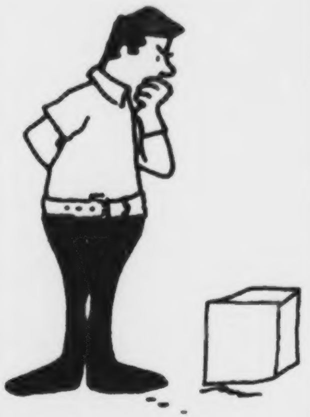
- Combustible metals



How to Lift Safely

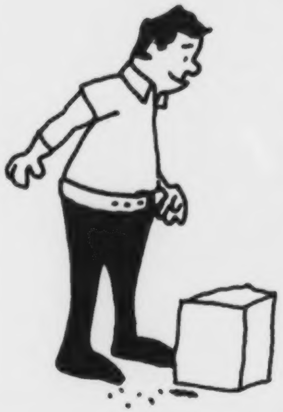
1

Approach the load and size it up as to weight, size, and shape. Consider your physical ability to handle the load.



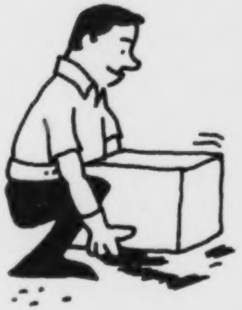
2

Place feet close to the object to be lifted and 8 to 12 inches apart for good balance.



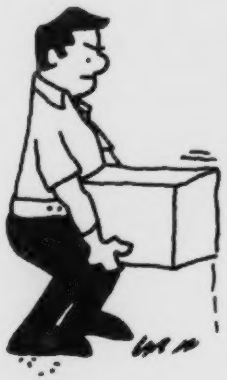
3

Bend the knees to the degree that is comfortable and get a good handhold. Then using both leg and back muscles. . .



4

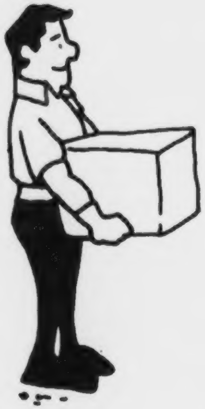
Lift the load straight up smoothly and evenly. Push with your legs, and keep the load close to your body.



How to Lift Safely (Continued)

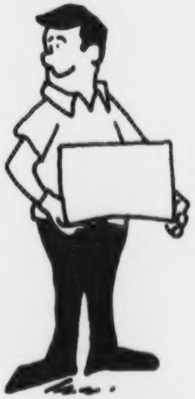
5

Lift the object into carrying position, making no turning or twisting movements until the lift is completed.



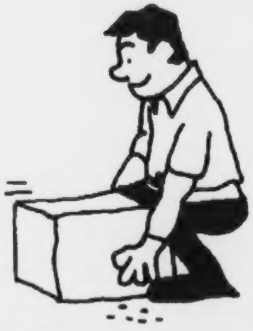
6

Turn your body with changes of foot position after looking over your path of travel, making sure it is clear.

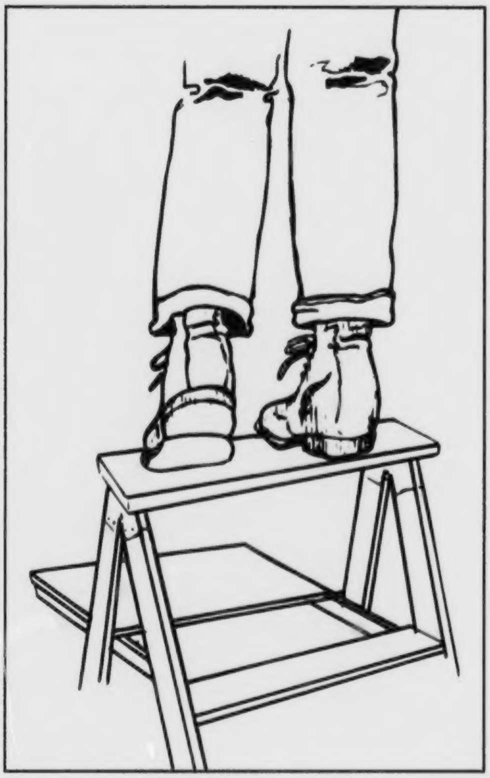


7

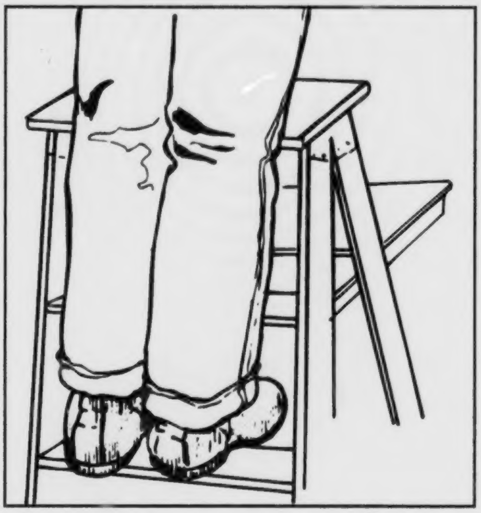
Setting the load down is just as important as picking it up. Using leg and back muscles, comfortably lower load by bending your knees. When load is securely positioned, release your grip.



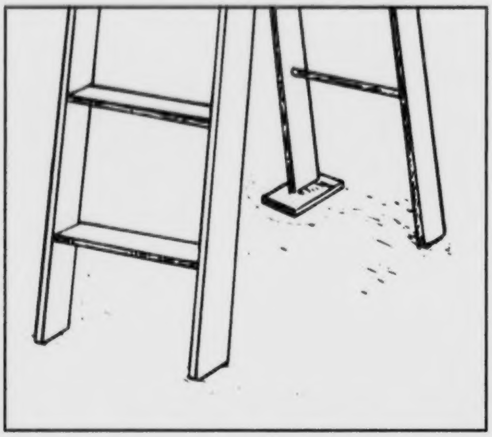
Safety Practices for Step Ladders



Incorrect



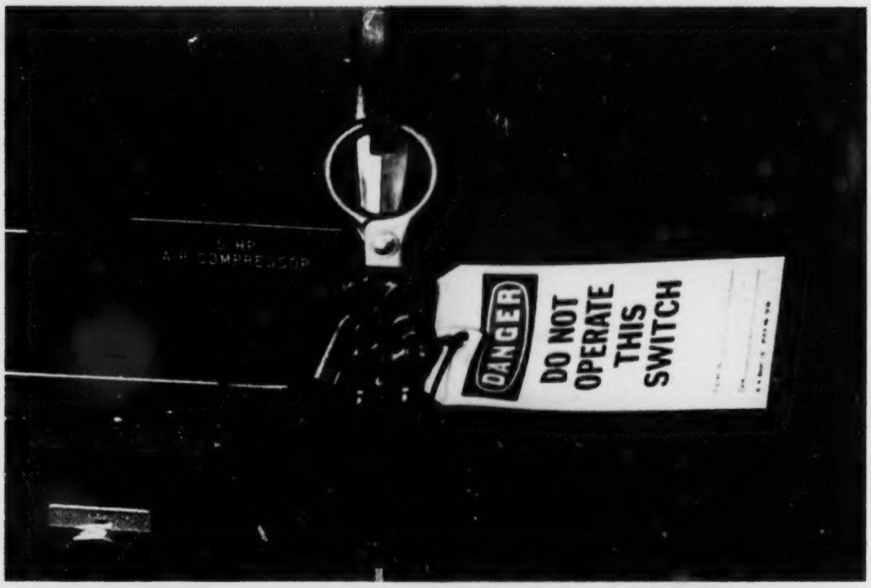
Correct



Use block to level ladder when necessary.

Lockout/Tagout

LOCK OUT FOR
SAFETY
Shortcuts
Cause
Accidents


5 HP
AIR COMPRESSOR
DANGER
DO NOT
OPERATE
THIS
SWITCH

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Unit 3

Welding Safety and First Aid

Unit Contents

Teacher Components

Teacher Page

Suggested Activities 3–3

Answers to Assignment Sheets 3–9

Written Test 3–11

Answers to Written Test 3–23

Transparency Masters

- 1—Golden Rules for Welding 3–27
- 2—Eye and Face Protection 3–29
- 3—Good Samaritan Law 3–31
- 4—Dangers of Rescue Procedures 3–33
- 5—Dangers of Rescue Procedures (continued) 3–35

Student Components

Student Page

Learning Activities Sheet 3–3

Objective Sheet 3–5

Information Sheet 3–7

Student Supplements

- 1—Lens Shade Selection Charts 3–31
- 2—A Systematic Look at First Aid 3–33

*Assignment Sheet

- 1—Determine Basic First Aid Measures for Given Emergency Situations 25

*The Assignment Sheet is located in the Student Workbook.

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make copies of any teacher supplements that will be provided for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

  TM 1—Golden Rules for Welding (Objective 1)
  TM 2—Eye and Face Protection (Objective 5)
  TM 3—Good Samaritan Law (Objective 16)
  TM 4—Dangers of Rescue Procedures (Objective 19)
  TM 5—Dangers of Rescue Procedures (continued) (Objective 19)

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Suggested Activities

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheet. Review with students the criteria for evaluation of this activity.

Teaching Suggestions

- Have a Red Cross representative or school nurse demonstrate first-aid techniques and discuss the dangers of bloodborne pathogens.
- Invite a local representative of the Compressed Gas Association to class to discuss the safe handling of, and the hazards associated with the improper handling of, compressed gas cylinders.
- Have a local OSHA inspector talk to the class about OSHA rules and regulations.
- Invite a certified CPR instructor to conduct a class and certify students in administering CPR.
- Discuss the Good Samaritan Act and your state's policy on using lifesaving techniques in emergency situations (see TM3).
- Show the first aid kit available in your classroom/shop. Discuss the contents of the kit and which items are used the most.
- Invite a member of your local emergency medical service team to speak to the class about precautions that rescuers should take to avoid contact with blood and body fluids that may be contaminated by HIV and hepatitis B.
- Have students role play how to give first aid for the various emergencies discussed in this unit. Have students alternate between the roles of victim and rescuer. **Caution** students not to use actual breaths for mouth-to-mouth, breaths or chest compressions for CPR, or thrusts for Heimlich during the role playing, but they can show you when those steps would be appropriate in an actual emergency.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.
- Evaluate the assignment sheet. Rate the student using the criteria listed on the assignment sheet. See Answers to Assignment Sheet for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.
- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- Connor, Leonard P., ed. *Welding Handbook, Eighth Edition, Vol. 1, Welding Technology*. Miami, FL: American Welding Society, 1987.
- Fortney, Clarence and Mike Gregory. *Introduction to Welding*. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1984.
- Kaltwasser, Stan. *Basic Wiring*, "Unit 2—General Safety and First Aid." Multistate Academic and Vocational Curriculum Consortium Inc., 1999.
- O'Brien, R. L., ed. *Welding Handbook, Eighth Edition, Vol. 2, Welding Technology*. Miami, FL: American Welding Society, 1991.
- *OSHA Safety and Health Standards (29 CFR 1910)*, Revised. Washington, DC: U.S. Department of Labor, Occupational Safety and Health administration, 1981.
- Walker, Susan S. *Introduction to Hospitality and Tourism*, "Unit 3—Basic Workplace and Safety and First-Aid Skills." Mid-America Vocational Curriculum Consortium Inc., 1993.

Suggested Activities

Suggested Supplemental Resources

Print Media

- *The Welding Handbook, Eighth Edition, Vol. 1, Welding Technology* is a substantial source for welding safety information in a variety of categories. *Vol. 2, Welding Processes* also contains vital safety information. Both texts are highly recommended references that every welding program should have available for both reference and instruction. The books are available with an education discount from:

  Order Department

  American Welding Society
  550 Northwest LeJeune Road
  P.O. Box 351040
  Miami, FL 33135
  800-334-9353
  www.aws.org

- *American Red Cross: Adult CPR.* American National Red Cross.

  Note: Contact your local Red Cross chapter to order the most recent edition of this publication.

- *American Red Cross: First Aid and Safety Handbook.* American National Red Cross.

  Note: Contact your local Red Cross chapter to order the most recent edition of this publication.

Electronic Media

Videotapes:

- Health and Safety Factors in Welding (27 Minutes)

  Excellent program to educate welders on potential health and safety concerns in this occupation.

- Health Factors in Welding Operations (28 Minutes)

  Excellent program for welders. Explains a variety of precautions, possible health problems involved in welding operations, and tips on how to generally improve your health.

- Safe Use of Compressed Gas Cylinders (8 Minutes)

  Designed for anyone using compressed gas cylinders. Explains basic safety procedures, compressed gas cylinder hazards, and how to properly use these cylinders.

- Safe Handling of Compressed Gas Cylinders (9 Minutes)

  Explains how to handle cylinders, proper storage, and general safe handling procedures.

- Bloodborne Pathogens in the Workplace (9 Minutes)

  Designed as an information/training video for workers who normally are not exposed to blood or body fluids, but an important part of providing precautionary information to workers.

- Eye Protection—A New Approach (humorous) (16 Minutes)

  This video approaches the problem of employees not wanting to wear safety glasses. Produced with some humor, but stresses the need for proper eye protection.

- Heat Stress (humorous) (17 Minutes)

  This video discusses heat stroke, heat stress, fainting, and precautions to take when working in a hot environment.

  Order the preceding videos from MAVCC at www.mavcc.org, or call (800) 654-3988. Most videos are available in CD-ROM format.

Internet:

- Compressed Gas Association
  www.cganet.com

- Occupational Safety and Health Administration (OSHA)
  www.osha.gov

- American Red Cross
  www.redcross.org

- American Welding Society
  www.aws.org

Answers to Assignment Sheet

Assignment Sheet 1

Determine Basic First Aid Measures for Given Emergency Situations

1. Jane is probably suffering from heat stroke. Have someone call 911, and notify your supervisor. Move Jane to a cool location (outside or air-conditioned office). Cool her as quickly as possible. Remove her outer clothing and sponge bare skin with cool water or rubbing alcohol. Place cold packs at neck, armpits, head, and groin. Use fans for additional cooling.

2. Gary appears to have a third-degree burn. Have someone call 911, and notify your supervisor. Cool burned area with a damp compress (no ointment) and cover with dry, sterile dressing. Cover Gary with a blanket to prevent heat loss.

3. The customer appears to be suffering from shock as well as minor bleeding. Have someone call 911, and notify your supervisor. Treat for shock first—lay her down on her back or side if she starts vomiting. Elevate her legs, cover her to prevent heat loss, and loosen her clothing if necessary. Now treat the bleeding—Put on your disposable gloves, cover wound with dressing, and apply pressure until bleeding stops. Notify designated personnel to clean up any materials or surfaces contaminated by blood or body fluids.

4. Robert appears to be unconscious because of the electrical shock he received when electricity and water made a connection. Have someone call 911, and notify your supervisor. Turn off the electricity at the master power switch in the shop. Check Robert's breathing and pulse. Perform mouth-to-mouth breathing or CPR if necessary and if qualified. Watch for signs of traumatic shock, and treat as necessary. Check for signs of electrical burns at entrance wound and exit wound, and treat as necessary.

5. Your supervisor Susan has a severe cut and possible head injury. Have someone call 911, and notify any other supervisors in the building. Lay Susan flat. Check her breathing and pulse. Perform mouth-to-mouth breathing or CPR if necessary and if qualified. Now treat the bleeding—Put on your disposable gloves, cover wound with dressing, and apply pressure until bleeding stops. Watch for signs of shock, and treat as necessary. Notify designated personnel to clean up any materials or surfaces contaminated by blood or body fluids.

6. Ask Ted if he is choking. Administer the Heimlich maneuver by standing behind him, wrapping your arms around his middle, placing your fist on the area above his belly button, and applying quick, upward thrusts until the food is expelled. If this does not work immediately, have someone call 911 and your supervisor, but keep trying the thrusts.

Answers to Assignment Sheet

7. Lisa's minor cut needs antiseptic ointment and a bandage. Try to convince her to let you help or go get the first aid supplies so Lisa can do it herself. If she still refuses help, notify your supervisor. Emergency 911 help is not necessary in this case.

8. Jorge appears to have a serious eye injury. Have someone call 911, and notify your supervisor. Have Jorge close both of his eyes and apply a sterile dressing and a loose bandage. Do not let him rub his eyes.

9. Angela appears to have a closed fracture of her left arm. Have someone call 911, and notify your supervisor. Immobilize Angela's arm with splints, sling, or wraps, or wait for help and let them immobilize it. Do not move Angela.

10. Your supervisor Steve appears to be having a heart attack. Have someone call 911, and notify any other supervisors in the building. Have Steve sit or lie down, whichever is more comfortable. Loosen his clothing around his neck and midriff. Check his breathing and pulse. Perform CPR if necessary and if qualified.

Written Test

Name ____

Date _______________________________ Score__________

Objective 1

Match the terms related to welding safety and first aid with their definitions.

1. Acquired Immune Deficiency Syndrome (AIDS)
2. Anaphylactic shock
3. Arc burn (flash burn)
4. Cardiopulmonary resuscitation
5. Electrical shock
6. First aid
7. First-degree burn
8. Hepatitis
9. OSHA
10. Safety
11. Second-degree burn
12. Third-degree burn

_____ a. Freedom from danger, risk, or injury

_____ b. Burn that destroys all skin layers and underlying tissue; characterized by white, leathery appearance and lack of pain

_____ c. Burn affecting only the outer skin layers; characterized by redness and pain

_____ d. A burn on the exterior membrane of the eye caused by exposing the naked eye to the ultra-violet and infrared rays in the flash of an electric arc, or the exposure of improperly covered body areas to the flash of an electric arc

_____ e. Immediate temporary care given the victim of an accident or sudden illness until the services of a physician can be obtained

_____ f. Severe and sometimes fatal reaction to an antigen (as bee venom); characterized by respiratory symptoms, fainting, and itching

_____ g. Infectious disease marked by inflammation of the liver

_____ h. Life-threatening bloodborne virus that depresses the cells of the immune system

_____ i. Procedure for restoring normal breathing after cardiac arrest

_____ j. Burn penetrating beneath the superficial skin layers; characterized by swelling and blisters

_____ k. Federal legislation designed to ensure safe and healthful working conditions for employees

_____ l. The sudden stimulation of nerves and muscles caused by the discharge of electricity through the body when the body contacts an energized electrical circuit

Written Test

Objective 2

Complete statements about the ALWAYS rules for welding safety. Circle the information that best completes each statement.

a. Always wear suitable protective clothing and **(eye protection) (ear plugs)**.

b. Always keep a safe, **(open) (clean)** work area.

c. Always keep welding equipment in **(good condition) (an out-of-the-way place)**.

d. Always check welding areas to make sure they're **(safe to work in) (well lighted)**.

e. Always respect gas cylinders as **(dangerous and potentially lethal) (expensive and easy to damage)**.

f. Always make sure ventilation provides **(one to two) (three to four)** complete changes of air per hour.

g. Always **(trust) (look out for)** fellow students and coworkers.

Objective 3

Complete statements about the NEVER rules for welding safety. Circle the information that best completes each statement.

a. Never enter the welding shop without wearing **(safety glasses) (helmet and gloves)**.

b. Never weld, cut, or grind near **(fellow workers) (flammable or explosive materials)**.

c. Never use **(leak detector) (oil)** on gas cylinders, regulators, connections, or hoses.

d. Never permit **(an electrode holder) (bare hands)** to come in contact with a welding machine or a gas cylinder.

e. Never operate **(old) (ungrounded)** equipment.

f. Never cut or weld directly **(on concrete) (against cast iron)**.

g. Never arc weld or operate electrically powered equipment while standing **(on wet or damp floors) (in a poorly lighted area)**.

h. Never cut into barrels, drums, or any container that has not been **(purged) (opened)**, or filled with water.

i. Never **(hang) (ground)** electrical equipment to a building member or a piece of equipment attached to or part of a building.

j. Never engage in **(horseplay of any kind) (unsupervised welding)**.

Objective 4

Solve problems about protective clothing required for welding. Select the best solution to each of the following scenarios. Write the correct numbers in the blanks.

_____ a. For a welding job where there would be a danger that flying sparks might strike a welder around the head and ear area, what could make the situation safe?

1. Moving the job to a safer area.
2. Make sure the welder wears a welder's cap underneath the welding helmet and turns the bill to protect the ear opening on the side where sparks might fall.
3. Take a different welding position.

_____ b. For a welding job that poses the danger that flying sparks and metal splatter might fall on a welder's legs, what could make the situation safer?

1. Wear heavy leather boots that reach above the ankle, and cuffless pants.
2. Wear good gloves.
3. Wear a welding jacket.

_____ c. For a welding job that will require a welder to be welding out of position in a confined area, what could make the situation safer?

1. Have the welder move to another position.
2. Have the welder wear a leather jacket along with a welder's cap.
3. Have the welder wear a hard hat.

_____ d. For a welding job that poses the danger that flying sparks and metal splatter might strike a welder in the chest or arms, what could make the situation better?

1. Wear good gloves.
2. Wear a loose fitting polyester shirt with a good collar.
3. Wear heavy leather gloves with gauntlets, and a long sleeved shirt with pocket flaps.

Objective 5

Select true statements about wearing proper eye protection by placing an "X" in the blanks next to the true statements.

_____ a. Only safety glasses need to be worn when grinding, chipping, cutting, or shaping metal with any kind of power tool.

_____ b. Eye protection can be worn over prescription lenses provided it does not disturb the proper position of the prescription lenses.

_____ c. Do not wear plastic-coated lenses for welding or cutting.

_____ d. An electric arc can burn a contact lens to the cornea of the eye.

_____ e. Shade numbers are additive. A #4 and a #6 lens will give the same density as a #10 lens.

Written Test

Objective 6

Select solutions for hazards from arc rays. Select the best response to each of the following conditions. Write the correct numbers in the blanks.

_____ a. A welder is welding and wearing a welding helmet, the right lens shade, and safety glasses, but the welder is in a short sleeve shirt.

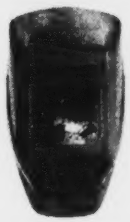
1. The welder is safe so long as welding is done in a hurry.
2. The welder needs to have hands, arms, legs, and torso covered with durable flame-resistant clothing.
3. The welder needs gloves with extremely long gauntlets.

_____ b. The arc flash from an arc welding station is clearly visible to people who have to walk to the shop office.

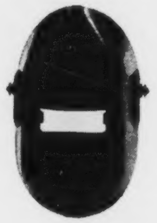
1. People should be directed to take another route.
2. People should be given shaded-lens glasses.
3. The work area should have a shield around it to contain the arc flash.

Objective 7

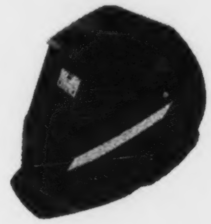
Differentiate between types of welding hoods. Place an "S" beside the illustration of a stationary filter lens helmet, an "F" beside the flip-front filter lens helmet, and an "A" beside the illustration of an auto-darkening helmet.



a. ____________________



b. ____________________



c. ____________________

Objective 8

Solve problems about guidelines for duty cycle safety. Select the best response to each of the following problems. Write the correct numbers in the blanks.

_____ a. You are working with a GTAW machine that has a duty cycle of only 10 percent. You know to:

1. Increase amperage to accomplish more welding in a shorter time.
2. Pay careful attention to the actual time you spend welding.
3. Stop every ten minutes to let the machine cool.

_____ b. You are working with a GTAW machine that has a 20 percent duty cycle. You estimate the welding job will take at least 30 minutes. You know to:

1. Operate the machine 6 minutes and then allow it to cool for 6 minutes.
2. The duty cycle will cover the entire time span so just complete the weld and be done with it.
3. Operate the machine no more than 2 minutes out of each 10 minute period.

Objective 9

Select true statements about important rules for handling welding cables and gas and coolant hoses by placing an "X" in the blanks next to the true statements.

_____ a. Never drag cables or hoses through dirt or oil, and never pull on a cable to force it over an obstruction.

_____ b. Use only solvent and rags to clean cables and hoses.

_____ c. When not in use, keep cables and hoses coiled free of kinks and properly stored.

_____ d. Never drape a welding cable over any type of gas cylinder, and NEVER strike an arc on a gas cylinder.

_____ e. Never interchange gas and water hoses without purging them first.

_____ f. Disconnect and remove electrode holders and cables used for SMAW.

_____ g. Keep cables off metal tables or any grounding surfaces.

_____ h. Make sure water-cooled systems have water turned off when shutting down.

_____ i. Use welding cable covers.

Objective 10

Complete statements about guidelines for oxygen safety. Circle the information that best completes each statement.

a. Since oxygen **(in storage) (under pressure)** may react violently in the presence of oil or grease, all oxygen fittings and equipment should be kept free of oil and grease.

b. Oxygen cylinders should never be stored near **(highly combustible materials) (any other fuels)** such as acetylene cylinders.

c. Oxygen should be **(used and stored) (stored)** with the valve end up.

d. **(Liquid) (Refrigerated)** oxygen cylinders have a double wall construction to help maintain a vacuum, and such cylinders should be handled with extreme care.

e. Avoid skin contact with **(liquid) (pressurized)** oxygen because its extremely low temperature can cause frostbite.

f. Oxygen cylinders should be protected against excessive **(cold) (temperature rises)**.

Written Test

Objective 11

Select true statements about guidelines for acetylene safety by placing an "X" in the blanks next to the true statements.

_____ a. Because acetylene burns readily, acetylene cylinders should be kept safely away from open flames.

_____ b. Acetylene cylinders should be stored in clean, dry, well ventilated locations free from other combustibles.

_____ c. Never withdraw acetylene from a cylinder at pressure over 10 psi.

_____ d. Never use acetylene from a cylinder that is lying on its side because acetone withdrawn with the acetylene could explode.

_____ e. Acetylene cylinders should be protected against excessive temperature rises.

Objective 12

Select true statements about guidelines for other fuel gas safety by placing an "X" in the blanks next to the true statements.

_____ a. Propane and MPS cylinders should be stored in clean, dry, well ventilated locations free from other combustibles.

_____ b. Both propane and MPS cylinders should be used and stored in an upright position.

_____ c. Natural gas in cylinders should be handled with the same precaution as other fuel gas cylinders.

_____ d. Whether used from a cylinder or from a piped-in supply, natural gas should be used just like other fuel gases.

Objective 13

Complete statements about guidelines for shielding gas safety by circling the word that best completes each statement.

a. In all cases, shielding gases should be used and stored in **(a horizontal) (an upright)** position.

b. Avoid skin exposure to **(carbon dioxide and nitrogen) (carbon dioxide and helium)** because both gases are cold enough to cause frostbite.

c. Because they **(are potentially explosive) (can displace oxygen in the air)**, some nonflammable shielding gases such as argon, nitrogen, carbon dioxide, and helium should be stored in well ventilated areas.

Objective 14

Complete statements about rules for storing compressed gas cylinders by writing the word that best completes each statement.

a. Store cylinders on ______________________________ flooring only.

b. While stored, valve protection caps shall be in place and ____________________.

c. Compressed gas cylinders shall be secured in an ____________________ position at all times.

d. Inside of buildings, cylinders shall be stored in a well-protected, well-ventilated, dry location, at least feet ____________________ from highly combustible materials.

Objective 15

Complete statements about rules for moving compressed gas cylinders by circling the word(s) that best completes each statement.

a. Valve protection caps **(shall) (shall not)** be used for lifting cylinders.

b. Cylinders shall be moved by tilting and **(rolling) (bouncing)** them on their bottom edges.

c. When work is finished, when cylinders are moved at any time, or when cylinders are **(empty) (full)**, the cylinder valve shall be closed.

d. Cylinders containing oxygen, acetylene, or other fuel gases shall not be taken into **(work areas) (confined spaces)**.

Objective 16

List in order, the general steps for handling any emergency situation.

a. Step 1: ____

b. Step 2: ____

c. Step 3: ____

d. Step 4: ____

Objective 17

Complete statements concerning general guidelines for first aid emergencies by writing the word(s) that best completes each statement.

a. Before administering first aid, always have a ____________________ for what you do.

b. ____________________ the injured person that everything possible is being done.

c. Make ____________________ ____________________ about the accident including name of victim, time, place, cause or nature of the accident, and any first aid that was administered.

d. Do not ____________________ the victim's family because this is the responsibility of the school, the job site supervisor, or the medical facility.

e. Report all accidents and injuries to your instructor or job site supervisor, no matter how ____________________ they may seem.

Written Test

Objective 18

Describe basic first-aid procedures for various emergency situations.

Bleeding

a. Severe: ____________________

____

b. Minor: ____________________

____

Burns

a. Third-degree: ____________________

____

b. Second-degree: ____________________

____

c. First-degree: ____________________

____

d. Chemical: ____________________

____

e. Electrical: ____________________

____

Eye injury

a. Minor: ____________________

b. More severe injury: ____________________

c. Chemical injury: ____________________

Traumatic shock

a. ____________________

b. ____________________

c. ____________________

d. ____________________

Falls

a. Head injury: ____________________

____

b. Less severe falls: ____________________

____

Choking

a. ____________________

____

b. ____________________

____

Heart attack

a. ____________________

b. ____________________

c. ____________________

d. ____________________

Electrical accident

a. ____________________

b. ____________________

c. ____________________

d. ____________________

Heat exhaustion

a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____________________

f. ____________________

Heat stroke

a. ________________________________

b. ________________________________

c. ________________________________

d. ________________________________

Insect stings

a. Ordinary reaction: ________________________________

____

____

b. Allergic reaction: ________________________________

____

____

Seizure

a. ________________________________

b. ________________________________

c. ________________________________

d. ________________________________

e. ________________________________

f. ________________________________

Objective 19

Select facts about treating a victim of electrical shock. Write the correct numbers in the blanks.

_____ a. What is the first step in rescuing a victim of electrical shock?

1. Treating electrical burn
2. Deenergizing the power source
3. Treating traumatic shock
4. Restoring breathing and/or heartbeat

_____ b. As an extra precaution, and only after the electricity has been turned off, how should the victim of an electrical accident be moved?

1. By pushing the victim with a foot encased in a leather-soled shoe
2. By using a stick, rope, blanket, or other nonconductor to nudge or grasp the victim
3. By standing on a dry surface and jerking the victim quickly away from the electrical source
4. By running at the victim and knocking him or her clear with your body weight

_____ c. Which of the following tools should be used to turn off electricity at the scene of an electrical emergency?

1. Alligator clip
2. Voltmeter
3. Wood-handled axe or insulated cutters
4. Ground-fault circuit-interrupter

_____ d. Why should the rescuer at an electrical emergency call for assistance?

1. It takes two people to remove a victim from electrical contact
2. One person must perform surveillance on the power source to ensure that it is not reactivated
3. One person can call for medical assistance while the other provides first aid
4. It takes two people to perform the complex first aid measures necessary

_____ e. What should the rescuer do if the victim's pulse is detectable but breathing has stopped?

1. Administer mouth-to mouth resuscitation
2. Administer CPR
3. Administer Heimlich maneuver
4. Administer lung thump

_____ f. What should the rescuer do if the victim's heartbeat has stopped?

1. Administer mouth-to mouth resuscitation
2. Administer CPR
3. Administer Heimlich maneuver
4. Administer lung thump

_____ g. What is the first thing the rescuer should do when treating the victim's electrical burns?

1. Cover his or her own mouth and nose with clean handkerchief
2. Locate and treat both the entrance and exit wounds
3. Apply a cool, clean compress
4. Cover the wound with a sterile, dry dressing

_____ h. In what position should the victim's feet be when being treated for traumatic shock?

1. Level with head
2. Slightly below head level
3. Slightly above head level
4. Knees bent, feet at head level

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 10
b. 12
c. 7
d. 3
e. 6
f. 2
g. 8
h. 1
i. 4
j. 11
k. 9
l. 5

Objective 2

a. Eye protection
b. Clean
c. Good condition
d. Safe to work in
e. Dangerous and potentially lethal
f. Three to four
g. Look out for

Objective 3

a. Safety glasses
b. Flammable or explosive materials
c. Oil
d. An electrode holder
e. Ungrounded
f. On concrete
g. On wet or damp floors
h. Purged
i. Ground
j. Horseplay of any kind

Objective 4

a. 2
b. 1
c. 2
d. 3

Objective 5

b, c

Objective 6

a. 2
b. 3

Objective 7

a. S
b. F
c. A

Objective 8

a. 2
b. 3

Objective 9

a, c, d, f, g, h, i

Answers to Written Test

Objective 10

a. Under pressure
b. Highly combustible materials
c. Used and stored
d. Refrigerated
e. Liquid
f. Temperature rises

Objective 11

a, b, e

Objective 12

a, b, c

Objective 13

a. An upright
b. Carbon dioxide and nitrogen
c. Can displace oxygen in the air

Objective 14

a. Fireproof
b. Secured
c. Upright
d. 20

Objective 15

a. Shall not
b. Rolling
c. Empty
d. Confined spaces

Objective 16

a. Determine the type of emergency.
b. Notify the appropriate medical or law-enforcement authority.
c. Notify your supervisor.
d. Provide basic first aid, or seek assistance from other employees until proper authorities arrive.

Objective 17

a. Reason
b. Reassure
c. Accurate notes
d. Notify
e. Minor

Objective 18

Bleeding

a. Apply pressure dressing or manual pressure to wound.
b. Apply antiseptic solution and dress with sterile bandages.

Burns

a. Cool with a damp compress and then cover with a dry, sterile dressing; cover victim with a blanket to prevent loss of body heat.
b. Cool with a damp compress—taking care not to break blisters—and then cover with a dry, sterile dressing to prevent infection.
c. Hold under cold water; apply dry, sterile dressing.
d. Flush skin thoroughly with clean water.
e. Locate both entrance and exit burns, and treat as a third-degree burn.

Eye injury

a. Minor: Have the victim close his or her eyes; put a piece of moist cotton over the closed lid; place a bandage over the cotton; get the victim to a doctor as soon as possible.
b. More severe injury—Apply a sterile dressing, bandage *loosely*, and get medical help immediately.
c. Chemical injury—Flush eyes immediately at an eye-flushing station, or use a bottled, portable flushing solution; then seek immediate medical assistance.

Traumatic shock

a. Recognize the signs and symptoms of traumatic shock.
b. Lay victim down.
c. Elevate victim's legs slightly.
d. Cover to prevent loss of body heat.

Falls

a. Lay victim flat; control bleeding.
b. Check for injury and provide first aid as appropriate; do not move victim—or allow victim to move—if a neck or back injury is suspected.

Choking

a. Recognize the signs and symptoms of choking.
b. Perform the Heimlich maneuver.

Heart attack

a. Recognize the signs and symptoms of heart attack.
b. Help victim to a less painful position.
c. Loosen victim's clothing around the neck and midriff.
d. Apply CPR if required and you are qualified.

Electrical accident

a. Do **not** provide any medical assistance until all electrical current has been shut off.
b. Administer CPR if necessary.
c. Treat for traumatic shock.
d. Treat for electrical burns.

Heat exhaustion

a. Recognize the signs and symptoms of heat exhaustion.
b. Immediately move victim to a cool place.
c. Lay victim flat.
d. Elevate victim's feet slightly.
e. Remove as much of victim's clothes as possible.
f. Sponge victim with cool water.

Answers to Written Test

Heat stroke

a. Recognize the signs and symptoms of heat stroke.
b. Move victim to a cool location.
c. Cool victim as quickly as possible.
d. Rub ice on victim's extremities.

Insect stings

a. Scrape stinger sideways away from wound; wash wound with soap and water; apply ice to reduce swelling.
b. If possible, immediately transport victim to a hospital or doctor's office; if transportation is not immediately available, lay victim down or help victim to a position in which he or she can breathe more easily; elevate victim's legs if possible; while waiting for emergency help, remove stinger and perform first-aid actions for an ordinary sting.

Seizure

a. Help victim lie on the ground or floor if possible.
b. Do not try to restrain victim.
c. Clear area of hard or dangerous objects to protect victim from self-injury.
d. Remove victim's eyeglasses, if applicable, and loosen clothing in the head and neck area.
e. Turn victim to the side to allow saliva to drain from the mouth.
f. Transport victim to a hospital or doctor's office after the seizure has passed.

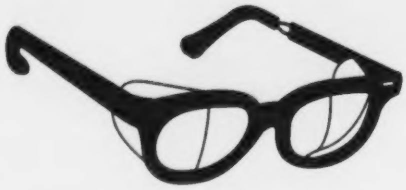
Objective 19

a. 2
b. 2
c. 3
d. 3
e. 1
f. 2
g. 1
h. 3

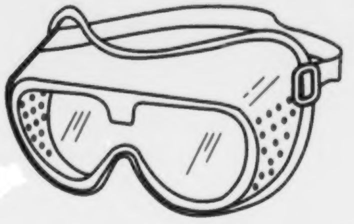
Golden Rules for Welding

If you open it, close it.
If you turn it on, turn it off.
If you unlock it, lock it.
If you break it, repair it.
If you can't fix it,
Call someone who can.
If you borrow it, return it.
If you use it, take care of it.
If you make a mess, clean it up.
If you move it, put it back.
If you don't know how to operate it,
Leave it alone.
If it doesn't concern you,
Mind your own business.

Eye and Face Protection

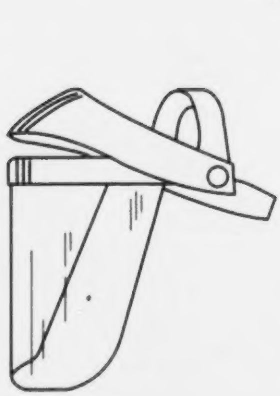


Safety Glasses

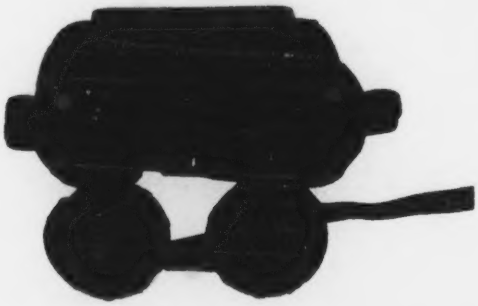


Flexible Goggles

Welding Helmets



Face Shield



Welding Goggles

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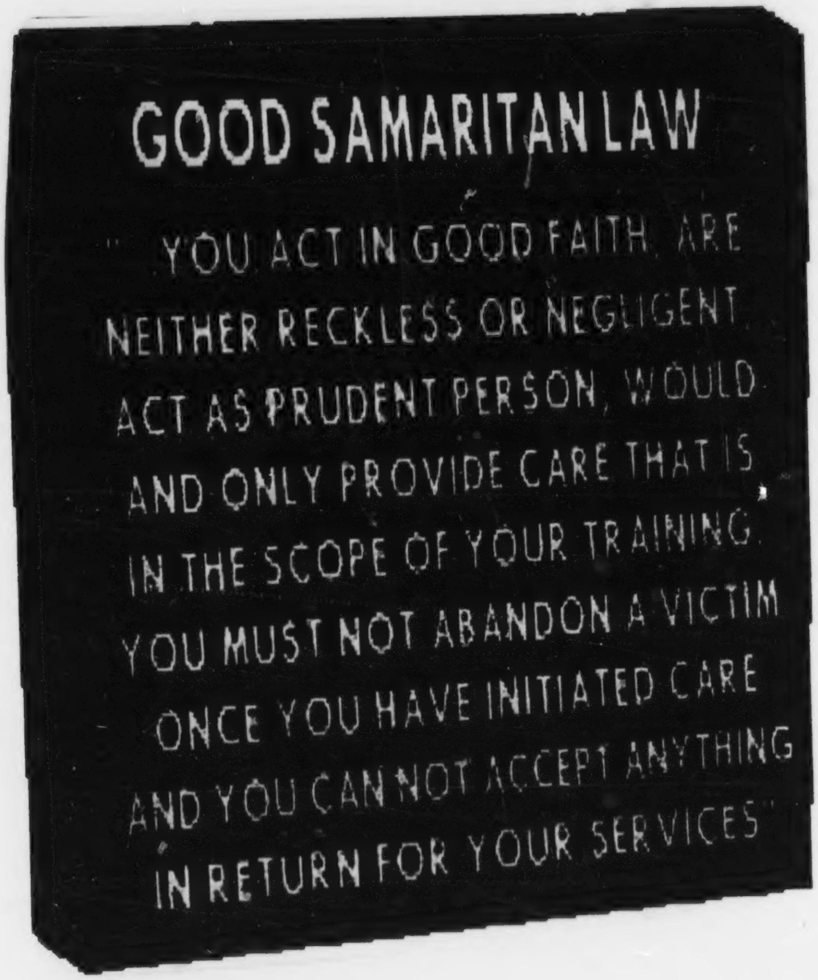
Good Samaritan Law

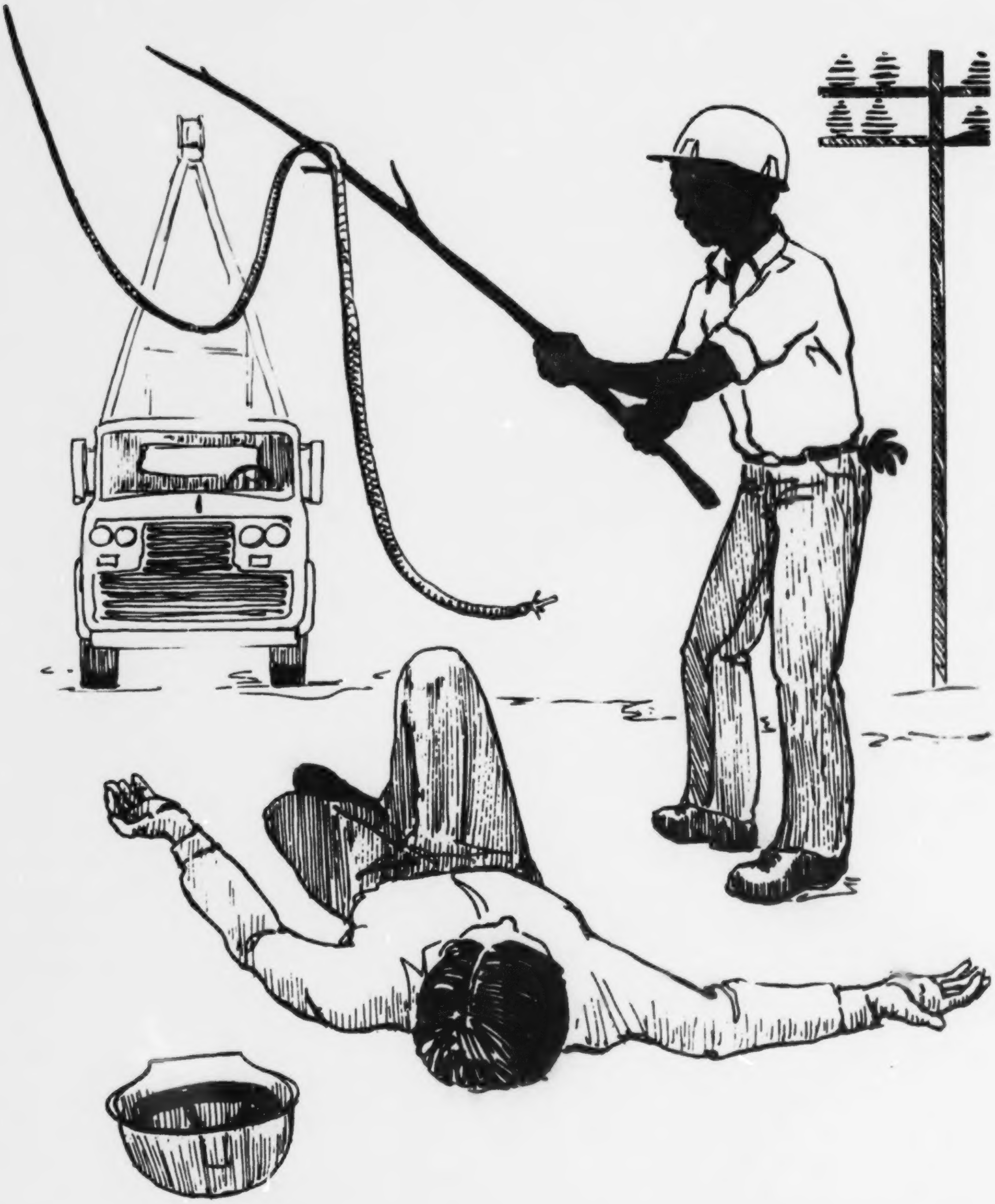


GOOD SAMARITAN LAW

"YOU ACT IN GOOD FAITH, ARE
NEITHER RECKLESS OR NEGLIGENT,
ACT AS PRUDENT PERSON, WOULD
AND ONLY PROVIDE CARE THAT IS
IN THE SCOPE OF YOUR TRAINING.
YOU MUST NOT ABANDON A VICTIM
ONCE YOU HAVE INITIATED CARE
AND YOU CAN NOT ACCEPT ANYTHING
IN RETURN FOR YOUR SERVICES"

BEST COPY AVAILABLE

Dangers of Rescue Procedures

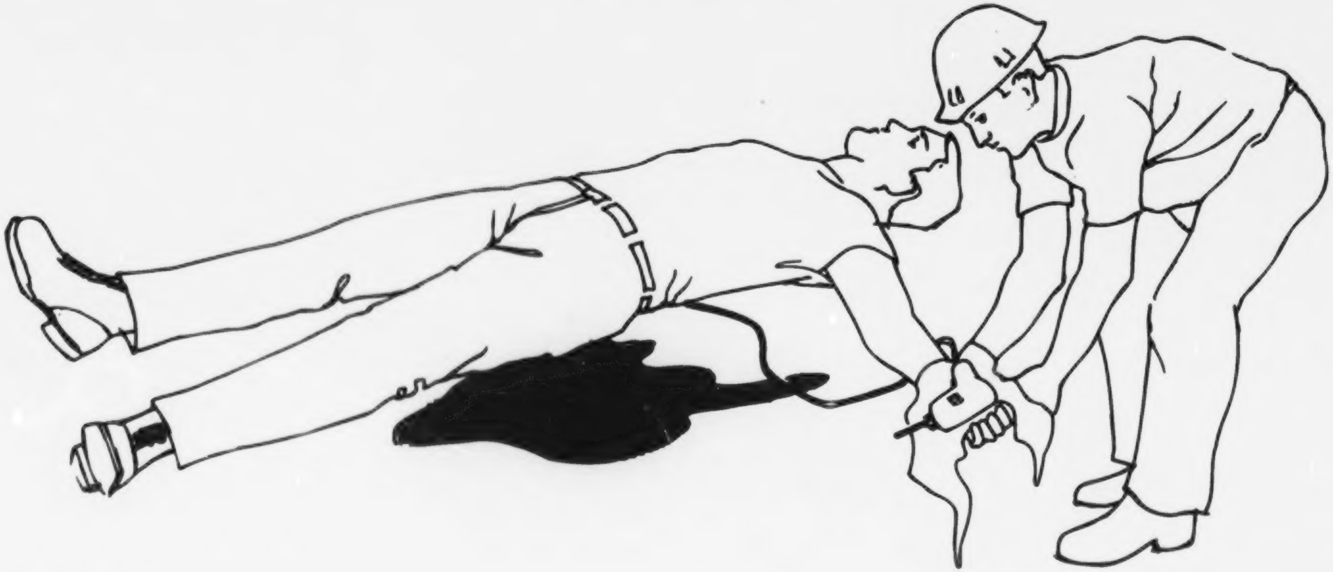


Use a nonconductor to separate victim from electrical circuit.

Do not touch the electrical circuit or the victim unless the power is off or you are insulated.

TM 4

Dangers of Rescue Procedures (continued)



Do not attempt to move a victim
without some form of insulation
such as paper or cloth to protect yourself.

Unit Contents

Teacher Page

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Student Components

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  1—Identify Basic Hand Tools 31
  2—Identify Basic Power Tools and Equipment 33

*Assignment Sheets are located in the Student Workbook.

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

  TM 1 and 2—Right and Wrong Tool Use (Objectives 21 and 22)

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.

Suggested Activities

Teaching Suggestions

- Have available the tools required for each objective. Demonstrate proper tool use as you teach each objective. Wear safety glasses or a face shield as required when demonstrating tool use. Impress students with the importance of learning how to properly use tools for not just the sake of safety, but for tool longevity and the protection of valuable working materials from damage through improper tool use.
- Take advantage of the objectives that discuss measuring and shaping tools to demonstrate how math functions in welding activities ranging from joint design to fit up. To enhance the "math concept", invite the carpentry instructor or a carpentry student from your school to demonstrate to the class how complex a simple framing square really is. Show how linear increments are used to find angles for roof pitch and rafter design. Use a bevel square to document all measurements.
- If you have a student who carries a tool box in the trunk of a car or on the back of a pickup, have the student estimate the cost of the tools that are there. Talk to students about the cost of tools. Stress these points when you teach the final objective on tool maintenance.
- Teach and reteach safety every chance you get, especially with Objectives 17 and 18 that deal with power equipment.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.
- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.

Resources Used in Developing This Unit

Print Media

- Althouse, Andrew D., et. al. *Modern Welding*. South Holland, IL: The Goodheart Willcox Co., Inc., 1989.
- Connor, Leonard P., ed. *Welding Handbook*, Eighth Edition, Vol. 1, Welding Technology. Miami, FL: American Welding Society, 1991.
- Fortney, Clarence and Mike Gregory. *Introduction to Welding*. Stillwater, OK: MidAmerica Vocational Curriculum Consortium, 1984.
- *Heavy Duty Power Tools for Industry and Construction*. Hampstead, MD: The Black & Decker Manufacturing Company, 1980.

- Moses, Napoleon W. *Hand Tools for Welding*. Mississippi State, MS: Research and Curriculum Unit for Vocational–Technical Education, College of Education, Mississippi State University, 1982.

Suggested Supplemental Resources

Print Media

- *Tools and Rules for Precision Measuring*

  The booklet contains information on a variety of precision measuring tools and how to use them. Also contains reference data and decimal equivalents. Over 150 illustrations. Available at no charge.

- *Tool Wall Chart*

  Displays 56 popular tools in full color. Tools include new electronics with digital readouts, calipers, micrometers, steel rules, assorted gages, squares, levels, etc. Available at no charge.

- *Educational Charts—set of 18*

  These charts help learners recognize basic tools, their principal parts, and uses. Tools illustrated include: micrometers, electronic micrometers and calipers, combination and bevel squares, hook rule, etc.

  The preceding instructional materials can be ordered from any *Starrett* distributor, or contact the *L.S. Starrett Company* at (800) 541-8887.

- *Welding Technology*

  The first volume of the American Welding Society's updated welding handbook series, dedicates Chapter 9 to fixtures and positioners. The chapter concludes with a supplementary reading list that offers many other useful resources too numerous to list here.

Electronic Media

Videotapes:

- Hand and Power Tool Safety (13 minutes)

  Excellent program to help reduce injuries when using hand and power tools. Explains electrical safety, impact tools, wrenches, etc. Emphasizes safety behavior and attitude.

  This video can be ordered online from MAVCC at www.mavcc.org, or by calling (800) 654-3988.

- Tool Training Series—set of six videotapes

  These videos take students through extensive step-by-step use-and-care of precision measuring tools, and includes hands-on demonstrations. Titles include: Outside Micrometer, Combination Set, Combination Square, Bevel Protractor, Vernier Caliper, and Vernier Height Gage. These videos are available as individual titles or as one video with all six tapes combined.

  Order from any *Starrett* distributor, or contact the *L.S. Starrett Company* at (800) 541-8887.

Suggested Activities

Internet:

- Proto Tools—excellent source for all types of hand tools. Complete online catalog
  www.swifco.com
- Cooper tools—home of the Crescent wrench. Complete online catalog
  www.coopertools.com
- Jancy tools—here you'll find cold saws, positioners, grinders, notchers, benders, and magnetic saws
  www.jancyslugger.com
- Grainger—online catalog of just about every type of tool needed in welding
  www.grainger.com
- Welding Supply—search for type of tool desired. Complete online catalog of all brands of hand and power tools
  www.weldingsupply.com
- L. S. Starrett Company—outstanding source for precision tools, gages, measuring instruments, and saw blades
  www.starrett.com

There are literally hundreds of internet sites for students to explore for purchasing hand and power tools. This is an excellent way to comparison shop for tools.

Answers to Assignment Sheets

Assignment Sheet 1

Identify Basic Hand Tools

a. Chipping hammer
b. Mallet
c. Ball peen hammer
d. Cold chisel
e. Drift punch
f. Card file
g. Wire brush
h. Screw-type C-clamp
i. Spring clamp
j. Wedge
k. Strongback
l. Hydraulic jack
m. Turnbuckle
n. Come-along
o. Plumb bob and line
p. Combination square

Assignment Sheet 2

Identify Basic Power Tools and Equipment

a. Power roll
b. Drill press
c. Pedestal buffer
d. Belt sander
e. Cut-off saw
f. Vertical band saw
g. Horizontal band saw
h. Turning roll
i. Positioner
j. Manipulator

Written Test

Name ______________________________

Date ______________________ Score __________

Objective 1

Match the terms related to welding tools and equipment with their definitions.

1. Hydraulic shear
2. Dies and punches
3. Gauge
4. Fixture
5. Pneumatic shear
6. Mechanical shear

_____ a. The measured thickness of metal or wire, or an instrument to measure thickness

_____ b. A form or frame used to mass produce a part or to control distortion during a welding process

_____ c. A metal-cutting machine with operating power from a clutch or a flywheel that provides high-speed operation

_____ d. A metal-cutting machine with operating power from fluid transport lines to provide a slower rate of operation than other shears

_____ e. A metal-cutting machine with operating power from compressed air transport lines to provide a slower rate of operation than other shears

_____ f. Extremely hard, precisely shaped, metal molds used on a press brake for forming angles and shapes in metal

Objective 2

Match driving and chipping tools with their characteristics and uses.

1. Mallets
2. Chipping hammer
3. Ball peen hammer
4. Fitter's or engineer's hammer
5. Sledge hammer

_____ a. Used to remove slag and residue left on metals after welding or cutting

_____ b. A heavy hammer with two driving heads used to drive wedges under and between materials; comes in weights of 40, 48, or 64 ounces

_____ c. Used where a metal hammer would dent or damage material; made of hickory, rawhide, lead, nylon, rubber, or other nonsparking materials

_____ d. A long-handled hammer used when more driving force is needed than a small hammer can deliver; comes in weights from 2 to 20 pounds

_____ e. A general purpose hammer with a curved face and a rounded head; comes in weights from 4 to 48 ounces

Written Test

Objective 3

Match chisels, punches, and pry bars with their uses.

1. Drift punch
2. Diamond-point chisel
3. ID stamp
4. Cold chisel
5. Aligning pry bar
6. Cape chisel
7. Round-nose chisel

_____ a. Used for cutting metal, rivets, nuts, and bolts

_____ b. Used for cutting keyways in metal

_____ c. Used for cutting V-grooves and cleaning out inside corners

_____ d. Used for cutting U-shaped grooves in metal

_____ e. Used for driving out straight or tapered pins

_____ f. Used for prying, positioning, and aligning parts in fit up

_____ g. Used to identify the welder who completed the work

Objective 4

Select true statements about characteristics and uses of files by placing an "X" in the blanks next to the true statements.

_____ a. Files are used manually to remove metal stock.

_____ b. The shape of a file may be triangular, flat, square, round or rat-tail, or half-round to provide a shape to match the job need.

_____ c. Basic file cuts range from single-cut coarse to double-cut smooth to provide textures that produce specific finishes.

_____ d. A card file is used to sharpen files.

_____ e. A file handle is used to cover the tang of a file and protect against injury.

Objective 5

Complete statements about types and uses of wire brushes by circling the information that best completes each of the following statements.

a. Wire brushes are used for cleaning a weld area (**before**) (**before or after**) welding.

b. Wire brushes have steel wire bristles or (**copper**) (**stainless steel**) bristles with shoe handles or bent handles.

Objective 6

Select true statements about vise-grip® clamps and their uses by placing an "X" in the blanks next to the true statements.

_____ a. Use a curve-jaw clamp to hold round objects like brads and rivet heads.

_____ b. Use a straight-jaw clamp to hold nuts and bolts, but do not use a straight-jaw clamp on brass fittings.

_____ c. Use a C-clamp to hold flat objects.

_____ d. Use a long-reach C-clamp to hold long, flat objects.

_____ e. Use a welding clamp to hold metal workpieces, especially heated stock that needs to be quenched.

_____ f. Use a sheet metal clamp to hold angle iron or other structural shapes.

_____ g. Use a chain clamp to hold or turn round stock, tube, or pipes.

Objective 7

Match holding and anchoring tools with their uses.

1. Spring clamps
2. Platen table
3. Vises
4. Screw-type C-clamps
5. Bar clamps

_____ a. Used to hold materials together until they can be joined by other means; these can hold longer and wider materials than other devices

_____ b. Used to hold two or more pieces of material together until they can be joined by other means; these are often used for distortion control

_____ c. Used for light duty to secure a tape line to workpiece or to secure light detail material onto a main workpiece

_____ d. Used to secure workpieces that cannot or should not be held with hand tools

_____ e. Used to eliminate welding and bending fixtures; has special accessories to assist with layout and welding activities

Written Test

Objective 8

Match alignment tools with their uses.

1. Wedges
2. Clip plates or dogs
3. Flat bar, yoke, and strongback

_____ a. Used to fit up two or more pieces of material by inserting a V-shaped end in between pieces so that striking the head or opposite end with a hammer will obtain vertical or horizontal alignment

_____ b. Used as a restraining device so that wedges can be applied and driven

_____ c. Used as restraining device so that wedges can be applied and driven in situations where other devices would not provide enough strength

Objective 9

Complete statements about types of jacks and their uses. Circle the information that best completes each statement.

a. (**Mechanical**) (**Hydraulic**) screw jacks and ratchet lever jacks are used to lift and hold materials in place at levels that make welding easier.

b. (**Mechanical**) (**Hydraulic**) jacks are used for lifting or lowering loads too heavy to be safely handled by other types of jacks.

Objective 10

Match pulling and lifting tools with their characteristics and uses.

1. Come-alongs
2. Plate dogs
3. Slings
4. Turnbuckles

_____ a. Used to adjust lengths of wire rope or steel rod; they are adjustable for taking up slack to induce a load or being slacked off to reduce a load

_____ b. Used as manually operated hoists; they are portable, easy to setup, and may be constructed with chain or cable

_____ c. Used to lift large, metal plates safely and move them from one place to another

_____ d. Cables and hooks or chains and hooks used in single, double, triple, or quadruple arrangement for lifting and moving heavy objects

Written Test

Objective 11

Match measuring tools with their characteristics and uses.

1. Rules
2. Calipers
3. American and U.S. standard metal gauges
4. Fillet gauge
5. Micrometers
6. Steel tape
7. Wing dividers
8. Drill point gauge
9. Undercut gauge
10. Pocket tape
11. Hi-lo gauge

_____ a. Used to measure work points and straight line distances up to 25 feet

_____ b. Used to measure work points and straight line distances greater than 25 feet

_____ c. Used to measure the thickness or gauge of sheet metal, steel plate, and wire

_____ d. Used to assure that drill tips being sharpened are kept centered at an angle of 59° so that they will cut faster with less applied force

_____ e. Used to construct small circles and arcs and transfer measurements

_____ f. Used for straight line measurements, but especially used for critical inside/outside measurements of holes, casings, and pipes

_____ g. Used to measure the inside, outside, or depth of parts that require tolerances

_____ h. Measuring devices graduated in whole units and fractions for measuring distances ranging from fractions of an inch up to 48 inches

_____ i. Used to measure fillet weld size

_____ j. Used to measure undercut depth

_____ k. Used to measure internal alignment and root weld spacing

Written Test

Objective 12

Match layout tools with their characteristics and uses.

1. Center punch
2. Bevel square
3. Plumb bob and line
4. Levels
5. Prick punch
6. Chalk line
7. Combination square
8. Framing square

_____ a. Used to check surface alignment horizontally, vertically, or at angles

_____ b. Used primarily by fitters to check the trueness of pipe flanges, but it is also used for checking bevel square angles

_____ c. Used to lay out bevels or to check materials cut on a bevel

_____ d. Used to square detail materials with the square head used for finding 45° and 90° angles, the protractor head for finding angles from 0° to 180°, and the center head for finding the center of round materials

_____ e. Used to check vertical alignment of related members in a project or workpiece

_____ f. Used to check for straightness in plate and structural metals

_____ g. Used to make puncture marks, to locate the centers of holes, or to establish work points or center lines on materials

_____ h. Used most often to make punch marks along layout lines to provide permanent references for chalked or scribed lines that might wear off in handling

Objective 13

Match turning tools and wrenches with their uses. Uses continue on the next page.

1. Screwdrivers
2. Allen wrenches
3. Torch wrenches
4. Adjustable wrench
5. Box-end wrench
6. Socket wrench sets
7. Pipe wrench
8. Torque wrench
9. Cylinder wrenches
10. Open-end wrench

_____ a. Used to tighten or loosen different sizes of nuts and bolts

_____ b. Used to tighten or loosen specific sizes of nuts and bolts

_____ c. Used to tighten or loosen specific sizes of nuts and bolts, but the head has closer control of the gripping surface than other types of wrenches

_____ d. Used primarily for fitting up pipe, but handy for holding and aligning because of its vise-like adjustable jaws

_____ e. Used specifically for tightening or loosening cylinder connections on oxyacetylene equipment because adjustable wrenches can easily damage the brass fittings used on oxyacetylene equipment

_____ f. Used specifically for tightening or loosening torch connections because adjustable wrenches or pliers can damage brass fittings

_____ g. Used to tighten or loosen specific types of screws, bolts, and other anchoring devices that have slotted heads

_____ h. Key-type wrenches used to tighten or loosen specific sizes of special screws or bolts

_____ i. Used with a variety of end sizes and handles to tighten or loosen different sizes of nuts and bolts that may be difficult to reach or require extra torque to tighten or loosen

_____ j. Used to tighten bolts to a specified value

Objective 14

Match pliers with their uses.

1. Needle nose
2. Diagonal cutters
3. Slip joint
4. Lineman's
5. Mig
6. Channel lock

_____ a. Used for handling hot metal or materials

_____ b. Used for cutting small diameter wire, especially wire used in gas metal arc welding

_____ c. Used for cleaning cups and nozzles, for cutting small diameter wire, for holding and bonding, and for general work around gas tungsten arc welding

_____ d. A multipurpose tool that can work as a wire cutter, a hammer or pliers, and can be used to clean and remove nozzles, and remove contact tips

_____ e. Used to cut larger diameter wire, for holding, and for general use around submerged arc welding

_____ f. Can be adjusted to hold a variety of metal thicknesses

Objective 15

Match manual cutting and shaping tools with their uses.

1. Straight-cut snips
2. Pipe cutters
3. Hacksaw
4. Tap and die sets
5. Bolt cutters

_____ a. Used to manually cut or separate metal

_____ b. Used to cut straight lines or curves on light-gauge metal

_____ c. Used to cut small diameter nuts, bolts, rod, and chain

_____ d. Used for cutting small-diameter pipe or tubing

_____ e. Used to cut inside threads in metal or to cut outside threads on pipe or other round stock

Written Test

Objective 16

Match manually-operated shop tools with their characteristics and uses.

1. Beverly shear
2. Anvil
3. Slip roller
4. Hossfeld bender
5. Floor brake

_____ a. Used to bend, form, and shape pipe, tubing, angle iron, flat bars, and straps

_____ b. Lever operated bench tool that makes distortion free cuts in straight or curved patterns on light to heavy metals

_____ c. An iron or steel block with both flat and curved surfaces for shaping metals that are hammered or peened against it

_____ d. Used to form cylinders, reverse curves, and radius bends of sheet metal

_____ e. Used for box, pan, and reverse bending of sheet metal

Objective 17

Match power equipment with their characteristics and uses. Uses continue on the next page.

1. Drill press
2. Belt sander
3. Pedestal buffer
4. Power roll
5. Press brake
6. Magnetic-based drill
7. Heavy duty hand drill
8. Angle iron cutter, notcher & bender
9. Angle and straight grinders
10. Bench grinder
11. Power shear
12. Hand drill

_____ a. Uses mechanical, hydraulic, or pneumatic power to cut all gauges of metal

_____ b. Used to shape both plate and structural metals into rounded forms

_____ c. Used for grinding all forms of metal

_____ d. Used on metals to polish or buff with wire, brush, or cloth wheels

_____ e. Generally used with attachments for cleaning joints before or after a welding process

_____ f. Used to grind or sand flat metal surfaces

_____ g. Generally used for light drilling jobs; designed with variable or reversible speed in 1/4", 3/8", and 1/2" sizes

_____ h. Generally used for drilling thick materials; designed with variable or reversible speed in 1/2", 3/4" and 1 1/4" sizes

_____ i. Used for drilling holes in several pieces of metal at one time or drilling single holes in heavier metal

_____ j. Used with different dies and punches to press metal into a desired shape

_____ k. Used for drilling magnetic materials up to 1 1/4" thick; magnet holds material in place while drilling

_____ l. Used to cut, notch, and bend this basic stock form

Objective 18

Match power saws with their characteristics and uses.

1. Reciprocating saw
2. Horizontal band saw
3. Cut-off saw
4. Cold saw
5. Vertical band saw
6. Power hacksaw

_____ a. Used with a continuous cutting blade for cutting mild steel

_____ b. Used with a continuous cutting blade to cut any length or type of metal

_____ c. Used with a reciprocating blade to cut any length or type of metal

_____ d. Used like a key-hole saw with various types of blades to cut wood, metal, plastic, and even heavy steel

_____ e. Used to cut heavier metal at different angles or in straight cuts

_____ f. Used to cut a wide variety of material shapes and sizes at an angle between 0° and 45° without producing heat or distortion

Objective 19

Match positioning equipment with their characteristics and uses.

1. Positioners
2. Manipulators
3. Turning rolls

_____ a. Used in production or with automatic equipment that requires pipes or round objects to be rolled

_____ b. Used to control and position welding equipment on automatic positioners or turning rolls in production shops with automatic welding processes

_____ c. Used to secure and position objects being welded; can turn or rotate an object at a preset speed or can be controlled manually by an operator

Objective 20

Complete statements concerning rules for hand tool safety by circling the material that best completes each statement.

a. Never use a (**screwdriver**) (**hammer**) as a prying tool.

b. Never use (**pliers**) (**socket wrenches**) to loosen or tighten nuts and bolts.

c. Never use any tool with a (**loose handle**) (**sharp edge**) or defective part.

d. When using a (**combination wrench**) (**screwdriver**), support the work on a bench or against a solid surface.

e. When using a wrench, (**pull it toward**) (**push it away from**) yourself to prevent smashing your hand if the wrench should slip.

f. Never use (**a file**) (**any tool**) without a handle.

g. Secure (**small**) (**large**) parts or objects before working on them with hand tools.

h. Never strike the mushroomed head of a (**punch or chisel**) (**screwdriver**).

Objective 21

Select true statements about rules for safe use of power tools and equipment by placing an "X" in the blank next to each true statement.

_____ a. Do not use power tools until you have been instructed how to safely use them, and have permission from your instructor.

_____ b. Check electrical cords and plugs before using electrical power tools, and check lines and connections before using air-operated tools.

_____ c. When working with a drill press, always clamp the workpiece in place or it will spin with the drill bit.

_____ d. Make sure shields and guards are removed if they obstruct a workpiece.

_____ e. Avoid walking into restricted safety zones marked off around power equipment.

_____ f. When using extension cords with power equipment, make sure they are extra long.

_____ g. Do not wear loose or frayed clothing around rotating equipment.

_____ h. Pay attention to safety signs and warning tags.

_____ i. Know emergency shut-down procedures for all power equipment.

_____ j. Keep tools clean and dry.

Objective 22

Select true statements about rules for tool and equipment maintenance by placing an "X" in the blanks next to each true statement.

_____ a. The number one rule for maintaining a tool or a piece of equipment is to use it only for its intended purpose.

_____ b. Tag and report any tool or piece of equipment suspected of being faulty.

_____ c. Record the type of service and date information placed on lubrication and maintenance schedules.

_____ d. Always disconnect the power supply when performing maintenance on power tools and equipment.

_____ e. Check tool rests on grinders monthly.

_____ f. Check grinding wheels monthly and dress as needed.

_____ g. Check oil pressure on shears monthly.

***Permission to duplicate this test is granted.**

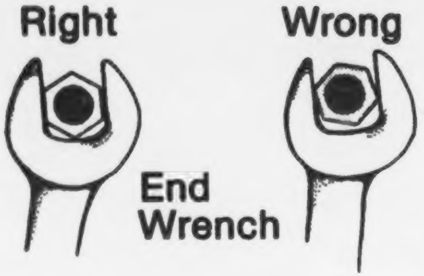
Answers to Written Test

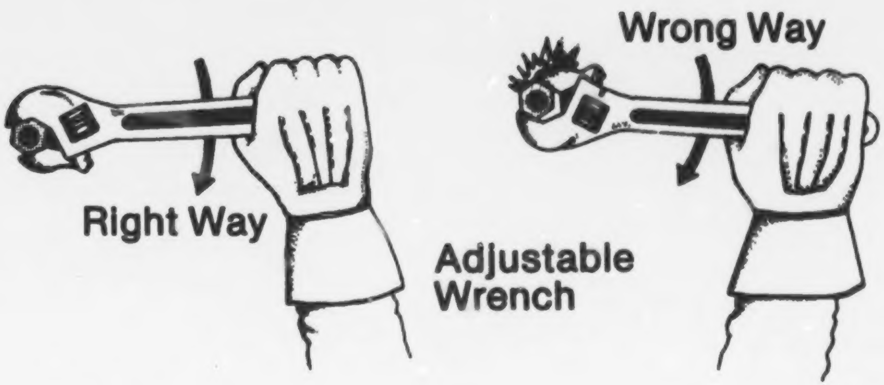
Objective 1	a.	3	d.	1		
	b.	4	e.	5		
	c.	6	f.	2		
Objective 2	a.	2	d.	5		
	b.	4	e.	3		
	c.	1				
Objective 3	a.	4	e.	1		
	b.	6	f.	5		
	c.	2	g.	3		
	d.	7				
Objective 4	a, b, c, e					
Objective 5	a.	Before or after				
	b.	Stainless steel				
Objective 6	a, b, e, g					
Objective 7	a.	5	d.	3		
	b.	4	e.	2		
	c.	1				
Objective 8	a.	1				
	b.	2				
	c.	3				
Objective 9	a.	Mechanical				
	b.	Hydraulic				
Objective 10	a.	4				
	b.	1				
	c.	2				
	d.	3				
Objective 11	a.	10	e.	7	i.	4
	b.	6	f.	2	j.	9
	c.	3	g.	5	k.	11
	d.	8	h.	1		
Objective 12	a.	4	e.	3		
	b.	8	f.	6		
	c.	2	g.	1		
	d.	7	h.	5		

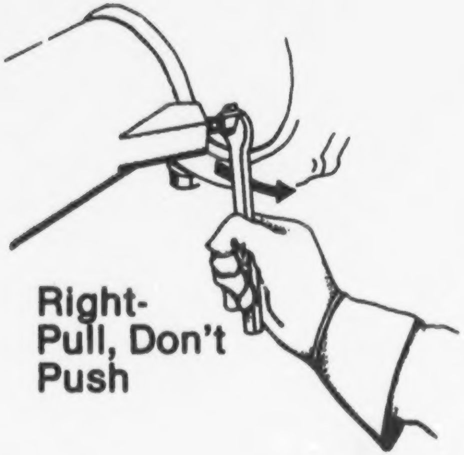
Answers to Written Test

Objective 13	a. 4	d. 7	g. 1	j. 8
	b. 10	e. 9	h. 2	
	c. 5	f. 3	i. 6	
Objective 14	a. 3	d. 5		
	b. 2	e. 4		
	c. 1	f. 6		
Objective 15	a. 3	d. 2		
	b. 1	e. 4		
	c. 5			
Objective 16	a. 4	d. 3		
	b. 1	e. 5		
	c. 2			
Objective 17	a. 11	d. 3	g. 12	j. 5
	b. 4	e. 9	h. 7	k. 6
	c. 10	f. 2	i. 1	l. 8
Objective 18	a. 5	d. 1		
	b. 2	e. 3		
	c. 6	f. 4		
Objective 19	a. 3			
	b. 2			
	c. 1			
Objective 20	a. Screwdriver			
	b. Pliers			
	c. Loose handle			
	d. Screwdriver			
	e. Pull it toward			
	f. A file			
	g. Small			
	h. Punch or chisel			
Objective 21	a, b, c, e, g, h, i, j			
Objective 22	a, b, c, d			

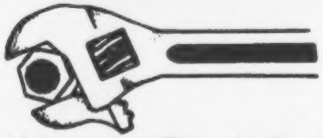
Right and Wrong Tool Use


Right
Wrong
End Wrench

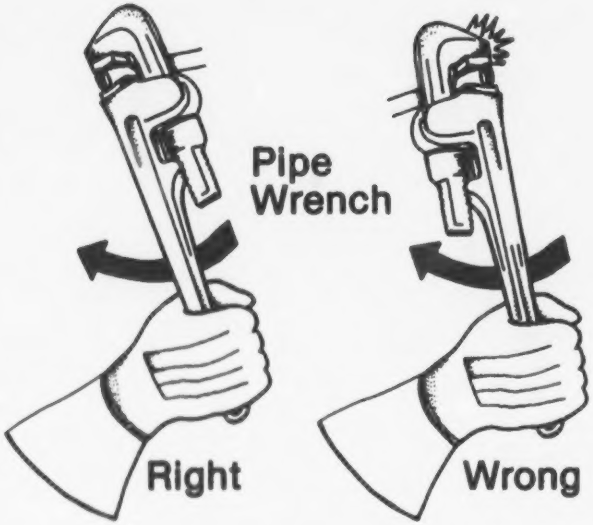

Wrong Way
Right Way
Adjustable Wrench


Right-
Pull, Don't
Push

End Wrench-
Adjustable Wrench

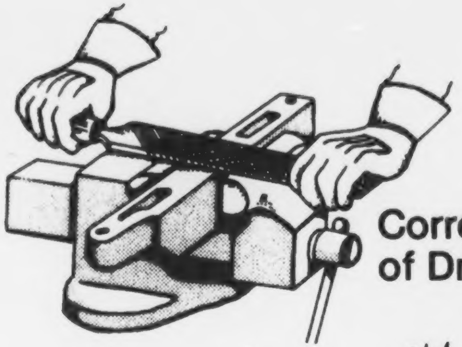


Wrong - Don't Pull on an Adjustable Wrench Until It has Been Tightened on the Nut

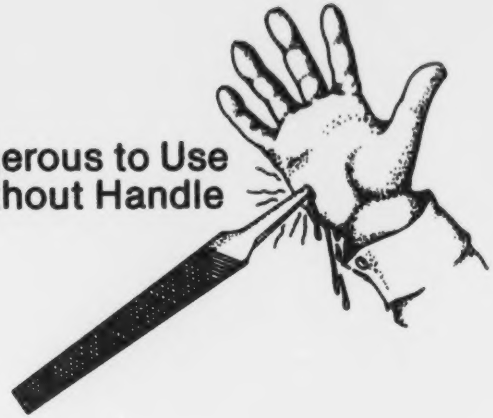

Pipe Wrench
Right
Wrong

MAVCC—Fundamentals of Welding

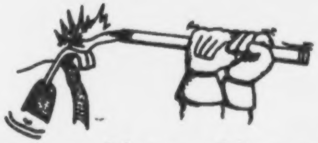
Right and Wrong Tool Use (Continued)



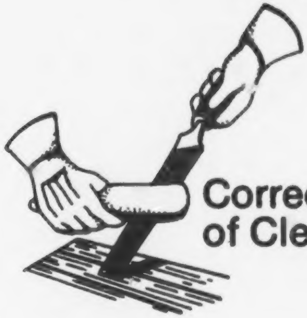
Correct Method of Draw-Filing



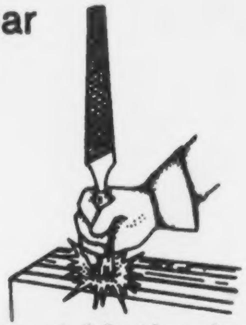
It is Dangerous to Use a File Without Handle



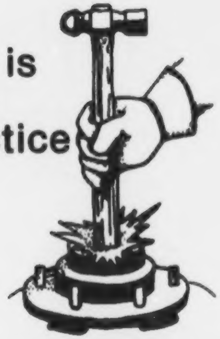
Wrong - Never Use a Bar or a Pipe on a Wrench



Correct Method of Cleaning a File



Correct Method of Tightening File Handle



This is Bad Practice

Incorrect Use of a Hammer

TM 2
T 4-23

Unit 5 Basic Metals and Metallurgy

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*Assignment and Job Sheets are located in the Student Workbook.

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make copies of any teacher supplements that will be provided for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

TM 1 and 2—Spark Test Characteristics (Objective 24)
TM 3—Metal Melting Points and Other Temperatures (Objectives 5, 6, 7, and 8)
TM 4—Aluminum Hardness and Tempering Designations (Objective 18)

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.

Suggested Activities

- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheet. Review with students the criteria for evaluation of this activity.
- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- This is a long unit of instruction. Teach the unit in related segments, and break the test up to reflect the segments so students will not be faced with an extremely long test. Objectives 25 through 30 concern themselves with residual stresses and distortion and how to control them. Teach these objectives together and provide adequate demonstration of items related to distortion control. Ideally, this part of the unit should be integrated with the teaching of Oxyacetylene Welding or Shielded Metal Arc Welding. In other words, provide students the opportunity to work with distortion control as it really happens on the job. Distortion control should be on students' minds in all welding activities.
- When teaching Objective 7, demonstrate thermal conductivity as it is shown in the objective. Have students assist with the demonstration so they will become personally involved.
- Using *The Procedure Handbook of Arc Welding* from The Lincoln Electric Company as a guide, discuss the weldability of different metals and alloys.
- Prepare a testing demonstration for Objective 22. If you have a Brinell or Rockwell tester, use it to demonstrate a hardness test. Prepare test coupons properly notched to demonstrate the Izod and Charpy tests. Have students help with the testing.
- Using section III of the *Welding Guide* from the Hobart Institute of Welding Technology as a guide, discuss the properties, identification, classification, and welding of metals.
- Forge or torch and twist different types of metals to illustrate residual stress.

- Demonstrate the equipment required for spark testing as it is outlined in Objective 23 and Job Sheet 3. Show students manufacturer's information about rpm adjustment for a stationary or a disc grinder. Demonstrate how to clean a grinding wheel with a wire brush. Next, demonstrate the spark testing procedure outlined in Objective 24. Have students help by getting involved with color identification and stream identification. Wait until last to demonstrate a nonferrous metal, and then grind a piece of ferrous metal long enough to clean the grinding wheel so it will be ready for use in Job Sheet 3. If you do grind aluminum, use a grinding wheel or disc designed to grind aluminum.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.

- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.

- Evaluate the assignment sheet. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheet for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.

- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

  Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

  Two sample performance evaluation keys have been provided on the next page. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

Suggested Activities

Sample A

4—**Skilled**—Can perform job with no additional training.
3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
1—**Unskilled**—Is familiar with process, but is unable to perform job.
0—**No exposure**—No information or practice provided during training program.

Sample B

Yes—Can perform job with no additional training.
No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- Connor, Leonard P., ed. *Welding Handbook, Eighth Edition, Vol. 1, Welding Technology*. Miami, FL: American Welding Society, 1987.
- Fortney, Clarence and Mike Gregory. *Introduction to Welding*. Stillwater, OK: MidAmerica Vocational Curriculum Consortium, 1984.
- Neely, John E. *Practical Metallurgy and Materials of Industry*. New York: John Wiley & Sons, Inc., 1979.
- *New Lessons in Arc Welding*. Cleveland, OH: The Lincoln Electric Company, 1981.
- O'Brien, R. L., ed. *Welding Handbook, Eighth Edition, Vol. 2, Welding Processes*. Miami, FL: American Welding Society, 1991.
- Repp, Victor E., Willar J. McCarthy and Oswald A. Ludwig. *Metalwork Technology and Practice, Seventh Edition*. Bloomington, IL: McKnight Publishing Company. 1982.
- *The Procedure Handbook of Arc Welding, Thirteenth Edition*. Cleveland, OH: The Lincoln Electric Company, 1994.
- *Welding Handbook, Eighth Edition, Volume 4, Materials and Applications–Part 2*. Miami, FL: American Welding Society, 1998.
- *Welding Kaiser Aluminum, First Edition*. Oakland,CA: Kaiser Aluminum and Chemical Sales, Inc., 1967.

Suggested Supplemental Resources

Print Media

- Brandt, Daniel A., and J.C. Warner. *Metallurgy Fundamentals*. Tinley Park, IL: Goodheart-Willcox Publishing, 1999.

  Order the preceding book online at www.goodheartwillcox.com, or call (800) 323-0440.

- Lancaster, John F. *Metallurgy of Welding, Eighth Edition*. Abington Press, 1999.
- Linnert, George E. *Welding Metallurgy, Fourth Edition*. Cleveland, OH: The Lincoln Electric Company, 1995.
- *The Procedure Handbook of Arc Welding, Thirteenth Edition*. Cleveland, OH: The Lincoln Electric Company, 1994.
- *Filler Metal Comparison Charts*. Cleveland, OH: The Lincoln Electric Company, 1993.

  Order the preceding books online from the Lincoln Electric Company at www.lincolnelectric.com, or contact your local Lincoln Electric dealer.

- *Welding Guide*. Troy, OH: The Hobart Institute of Welding Technology, 1995.

  Order the preceding book online at www.welding.org, or call (800) 332-9448.

Electronic Media

Videotapes:

- Prevention and Control of Distortion (20 minutes)

  Walt Disney Studios made this video especially for The Lincoln Electric Company. The video features an animated character named Mr. Shrink.

  Order the preceding video online from the Lincoln Electric Company at www.lincolnelectric.com, or contact your local Lincoln Electric dealer.

Internet:

The following companies and organizations offer a variety of information and publications on metallurgy.

- The Lincoln Electric Company
  www.lincolnelectric.com
- The Hobart Institute of Welding Technology
  www.welding.org
- American Welding Society
  www.aws.org

Answers to Assignment Sheet

Assignment Sheet 1

Identify Selected Metals By Appearance, Color, and Corrosion Characteristics

Evaluated according to written criteria.

Written Test

Name ______________________________

Date ______________________ Score __________

Objective 1

Match terms related to basic metals and metallurgy terms with their definitions.

1. Weldment
2. Compatibility
3. Metallurgy
4. Postheating
5. Strain-hardened
6. AISI
7. Filler metals
8. SAE
9. Preheating
10. AA
11. Interpass temperature
12. Extruding

_____ a. The science that explains the properties, behavior, and internal structure of metals

_____ b. Metals added in making a brazed, welded, or soldered joint

_____ c. Application of heat to a base metal before welding or cutting

_____ d. Maintenance of heat to a base metal and weld passes during a welding process

_____ e. Application of heat to a weld and/or a base metal after a welding operation to promote a slower cooling rate and relieve stresses in the base metal and the weldment

_____ f. Assembly of two or more metal parts with welding

_____ g. Two or more metals that have similar properties that can readily be joined

_____ h. American Iron and Steel Institute

_____ i. Society of Automotive Engineers

_____ j. The process of forcing a metal through a special die to give it shape and length

_____ k. Aluminum Association

_____ l. A metal that has had its strength, hardness, and brittleness increased with or without heating

Written Test

Objective 2

Select true statements about advantages of proper metal identification by placing an "X" in the blanks next to the true statements.

_____ a. Proper metal identification helps determine how many different welding processes would be possible for a particular metal.

_____ b. Proper metal identification helps establish requirements for preheating, interpass heating, and postheating.

_____ c. Proper metal identification helps establish what metals are incompatible so that proper filler metals can be selected.

Objective 3

Match terms related to basic metals, alloys, and properties with their definitions.

1. Physical properties
2. Alloy steels
3. Ferrous metals
4. Chemical properties
5. Alloy
6. Nonferrous metals
7. Mechanical properties

_____ a. Metals that contain iron as the major element

_____ b. Metals that contain no iron or an extremely small amount of iron

_____ c. A single element dissolved together with a metal or metals in a solid solution

_____ d. Steels formed by adding one or more additional elements to give the steels special properties

_____ e. The measure of how materials behave under applied loads

_____ f. Properties such as melting point or thermal conductivity which are affected when metals are subjected to heat

_____ g. Properties which involve corrosion, oxidation, and reduction

Objective 4

Select true statements about metal identification tests and their characteristics by placing an "X" in the blanks next to the true statements.

_____ a. Appearance—Surface color reveals the presence of oxidation; when exposed to weather, some metals will rust, others tarnish, and others remain oxidation free.

_____ b. Chemical—Certain chemicals or acids applied to metals cause different reactions in different metals.

_____ c. Chisel—When chipped with a chisel, certain metals produce a continuous chip, others break up into small particles, and others cannot be chipped.

_____ d. File—Ferrous metals are usually easy to file, but nonferrous metals are difficult to file.

_____ e. Magnet—A magnet sticks to nonferrous metals, but it will not stick to ferrous metals.

_____ f. Sound—When struck with a hammer, most metals have a characteristic ring or lack of it.

_____ g. Spark—Nonferrous metals have definite spark patterns, but ferrous metals have no spark pattern.

Objective 5

Match mechanical properties of metals with their characteristics.

1. Elongation
2. Hardness
3. Impact resistance
4. Strength
5. Fatigue
6. Ductility
7. Elastic limit
8. Malleability
9. Elasticity
10. Brittleness

_____ a. The capacity of metal to resist penetration, abrasion, and deformation

_____ b. The capacity of a metal to resist changing its shape or size when exposed to external forces

_____ c. The capacity of a metal to be permanently stretched without breaking

_____ d. The capacity of a metal to be hammered or rolled into shape without breaking

_____ e. The tendency of certain metals to break or fracture if bent or struck sharply

_____ f. The capacity of a metal to return to its original size and shape when the force that changed it is removed

_____ g. The incapacity of a metal to return to its original size and shape when the force that changed it is removed

_____ h. The tendency of some metals to break or fracture under a repeated or sustained load

_____ i. The capacity of a metal to absorb without failure the impact of a load applied rapidly

_____ j. The measure of ductility of material measured in a tension test

Written Test

Objective 6

Match types of mechanical strengths with their characteristics. Place the number of the characteristic in the appropriate blank.

1. Shear strength
2. Tensile strength
3. Torsional strength
4. Compressive strength

_____ a. The capacity of a metal to resist being pulled apart

_____ b. The capacity of a metal to resist being pushed or crushed together

_____ c. The capacity of a metal to withstand a sustained load across its cross section

_____ d. The capacity of a metal to resist twisting forces

Objective 7

Select true statements about physical properties of metals and their characteristics by placing an "X" in the blanks next to the true statements.

_____ a. Density is the weight of a given piece of metal in relation to a unit size.

_____ b. Electrical conductivity is the capacity of a metal to conduct electrical current.

_____ c. Thermal conductivity is the capacity of a metal to resist heat.

_____ d. Thermal expansion is the tendency of metals to expand when heated or cooled.

_____ e. Melting point is the point to which a metal must be heated before it will melt.

Objective 8

Solve problems about steel identification systems and their characteristics. Place the number of the information that best solves the following problems in the blank provided.

_____ a. A shipment of steel has just arrived at a welding shop. All the steel has the identification SAE 1010. What steel identification system is on the steel, and what does it mean?

   1. The Society of Automotive Engineers' ID system indicates that it is a stainless steel.
   2. The Society of Automotive Engineers' ID system indicates a low-carbon steel with a 10% carbon alloy.
   3. The ID system is unimportant because the steel has less than 25% carbon alloy.

_____ b. A shipment of steel has just arrived at a welding shop. Some of the steel has AISI C 1020 stamped on it, and the rest of the steel has a green bar painted on one end with four numbers painted in yellow. What steel identification system is on the steel, and what does it mean?

1. The ID system is from the American Iron and Steel Institute and indicates a low-carbon steel.
2. There are actually two ID systems on the steel. The AISI number indicates an open-hearth carbon steel product with 20% carbon alloy, and the color coding means to check the manufacturer's color code guide.
3. The AISI number indicates a low-carbon steel with only 2% carbon alloy, and the color code indicates the same.

_____ c. A shipment of steel has just arrived at a welding shop. All the steel is stamped S99995. What steel identification system is on the steel, and what does it mean?

1. It is an AISI identification system, and it means that it is a high-carbon steel.
2. It is a Unified Numbering System identification, and it means the product is stainless steel.
3. The S indicates "steel" and the numbers indicate a very high carbon content.

Objective 9

Complete a chart of carbon steel classifications, characteristics, and typical uses. Place the number of the typical uses in the appropriate blank.

Classification	Characteristics	Typical Uses
Low carbon	0.07% to 0.15% carbon	a. ____________
Mild steel	0.15% to 0.30% carbon	b. ____________
Medium carbon	0.30% to 0.50% carbon	c. ____________
High carbon	0.50% to 1.00% carbon	d. ____________

1. Axles, shafts, machine bolts, boilers, hammers, and sledges
2. Nails, iron bars and rods, auto bodies, and pipes
3. Screwdrivers, crow bars, axes, springs, razor blades, and fine cutters
4. Gears, shafts, bolts, metal frames, angles, and channels

Written Test

Objective 10

Match principal steel alloys with their uses. Place the number of the alloy in the appropriate blank.

1. Nickel
2. Silicon
3. Carbon
4. Cobalt
5. Chromium
6. Molybdenum

_____ a. Used to make steels hard and strong

_____ b. Used to make steels that will remain hard when subjected to very high temperatures

_____ c. Used to make special steels with improved ductility while maintaining strength and toughness and a high resistance to corrosion and shock

_____ d. Used to make special steels that are hard and brittle

_____ e. Produces the greatest hardening effect of any element except carbon

_____ f. Increases tensile strength and hardness, as well as resistance to corrosion and oxidation

Objective 11

Complete a chart of alloy steel classifications, characteristics, and typical uses. Place the number of the alloy steel in the appropriate blank.

Classification	Characteristics	Typical Uses
a. _____	Strong and hard, resists corrosion, withstands shocks, vibration, and wear	Wire cables, railroad and car axles, and steel rails
b. _____	Fine grain, tough and strong, resists corrosion, shocks, and scratches	Auto bearings and safes
c. _____	Does not corrode, has a bright silvery finish that looks good	Sinks, tables, and food service items subject to high standards of cleanliness
d. _____	Hard and strong	Auto gears, springs, axles, and armor plate
e. _____	Tough and strong, can resist strain, shock, and hammering	Jaws of rock crushers, chains, gears, and safes
f. _____	Tough and strong, resists heat and impact wear	Auto parts, high-grade machinery, and roller bearings
g. _____	Hard, fine grained, and resists heat	High-speed metal cutting tools
h. _____	Holds magnetism well	Electrical measuring instruments
i. _____	Hardest man-made metal	Cutting tools and dies
j. _____	Tough, but lightweight, fine grained, and resists shock	Auto axles, gears, and springs
k. _____	Extremely hard	Heavy cutting tools
l. _____	Self-hardening steel	Cutting tools, taps, and drills

1. Tungsten steel (magnet steel)
2. High chromium steel (stainless steel)
3. Vanadium steel
4. Nickel steel
5. Stellite steel
6. Chromium steel
7. Tungsten steel (tungsten carbide)
8. Manganese steel
9. High-speed steel
10. Chrome-nickel steel
11. Tungsten steel
12. Molybdenum steel

Written Test

Objective 12

Complete a chart of iron classifications, characteristics, and typical uses. Place the number of the characteristics in the appropriate blank.

Classification	Characteristics	Typical Uses
Wrought iron	a. ______	Rivets, bolts, nails, horseshoes, and ornamental iron
Gray cast iron	b. ______	Large pipes, stoves, water hydrants, and machinery frames
White cast iron	c. ______	Machine parts subjected to extreme wear or abrasion
Malleable cast iron	d. ______	Farm tools, implement parts, and railroad equipment

1. Very hard and brittle
2. Resists corrosion, withstands shock, is malleable and easy to bend hot or cold
3. Tougher and more impact resistant than other cast irons
4. Relatively inexpensive, high compressive strength, but low tensile strength and brittle

Objective 13

Complete statements concerning guidelines for identifying metals by color and characteristics by circling the material that best completes each of the following statements.

a. For low, medium, and high-carbon steels, look for new stock to be dark gray; these grades of steel **(rust) (tarnish)** with age, and rust rapidly when stored outside.

b. For manganese steels, look for a **(dull metallic) (glossy)** surface on new stock; these steels rust with age, and rust rapidly when stored outside.

c. For stainless steels, look for bright, silvery-smooth surfaces; **(all) (some)** grades of stainless rust with age and other grades tarnish.

d. For cast iron, look for a dull, gray color with evidence of the sand mold on new stock; cast irons rust rapidly **(in almost any environment) (when left outside)**.

e. For wrought iron, look for new stock to be light gray and smooth; wrought irons rust **(rapidly) (slowly)** in almost any environment.

f. For aluminum, look for new stock to have a silvery-white, smooth surface; this light-weight metal **(has high corrosion resistance) (has medium corrosion resistance)**.

g. For copper, look for a reddish-brown, dull finish on new stock; copper **(resists corrosion, but it will tarnish) (will corrode and tarnish)**.

h. For nickel, look for a hard, white finish; nickel **(resists corrosion) (is subject to corrosion)**.

Written Test

Objective 14

Select true statements about aluminum, its characteristics and uses by placing an "X" in the blanks next to the true statements.

_____ a. Aluminum is most used and most expensive of the nonferrous metals.

_____ b. Aluminum is a silvery-white metal with a brilliant surface beauty that resists corrosion and is maintenance free.

_____ c. Pure aluminum is very hard and difficult to use, so it is usually combined with an alloy to change its characteristics.

_____ d. Aluminum is a good conductor of electricity, an excellent thermal reflector when it is polished, and a good thermal conductor in other forms.

_____ e. Aluminum is both malleable and ductile and can easily be formed into shapes or into wire.

_____ f. Aluminum is available in sheets, plates, bars, wires, pipes, tubes, and a great number of extruded forms.

Objective 15

Complete statements about basics of the commercial system for identifying aluminum. Circle the material that best completes each statement.

a. The commercial system identifies aluminum by groups:

1. The 1 XXX group indicates aluminum of **(90%) (99%)** or higher purity.
2. The 2XXX group indicates aluminum with **(copper) (nickel)** as the principal alloying element.
3. The 3XXX group indicates aluminum with **(copper) (manganese)** as the principal alloying element.
4. The 4XXX group indicates aluminum with **(magnesium) (silicon)** as the principal alloying element.
5. The 5XXX group indicates aluminum with **(silicon) (magnesium)** as the principal alloying element.
6. The 6XXX group indicates aluminum with **(silicon and magnesium in approximate proportions) (titanium)** as the principal alloying element.
7. The 7XXX group indicates aluminum with **(zinc) (chromium)** as the principal alloying element.

b. In the commercial identification system, there is a **(six-digit) (four-digit)** ID system especially for group 1XXX, and another **(three-digit) (four-digit)** ID system for the 2XXX plus group.

Written Test

Objective 16

Select true statements about the 1XXX group commercial identification system by placing an "X" in the blanks next to the true statements.

_____ a. In the 1XXX group four-digit code, the first digit indicates a minimum of 90% aluminum.

_____ b. The second digit indicates the degree of special control of impurities, with 0 indicating no special control and 9 indicating the highest special control.

_____ c. The last two digits have no special significance except to the manufacturer.

Objective 17

Select true statements about the 2XXX plus group commercial identification system by placing an "X" in the blanks next to the true statements.

_____ a. In the 2XXX plus group four-digit code, the first digit indicates the major alloying element in the aluminum.

_____ b. The second digit indicates the amount of modification to the alloy, with 0 indicating no modification and 9 indicating the highest modification.

_____ c. The last two digits have no special significance except to the manufacturer.

Objective 18

Solve problems about other elements of commercial aluminum identification and their meanings. Place the number of the information that best solves the following problems in the blank provided.

_____ a. A worker sent to locate a strain hardened sheet of aluminum for a special job needs to look for what stamp on the sheet?

1. The letter O
2. The letter F
3. The letter H

_____ b. A worker sent to locate a thermally treated sheet of aluminum for a special job needs to look for what stamp on the sheet?

1. The letter H
2. The letter T
3. The letter O

Objective 19

Complete definitions of aluminum quality designations and their meanings. Write the correct information in the appropriate blank.

a. AQ—______________________ quality

b. CQ—______________________ quality

c. HTQ—______________________ quality

Written Test

Objective 20

Arrange in order the steps in using the commercial system to identify aluminum. Place a "1" beside the first step, and then list other steps in order.

_____ a. Determine the H or T designation.

_____ b. Determine the quality designation.

_____ c. Determine the number code series.

_____ d. Determine the degree of hardness.

_____ e. Determine the principal alloying element.

Objective 21

Match other nonferrous metals with their typical uses. Place the number of the nonferrous metal in the appropriate blank.

1. Nickel
2. Silver
3. Titanium
4. Tin
5. Copper
6. Gold
7. Zinc
8. Beryllium
9. Magnesium
10. Lead

_____ a. Used in electric and telephone wires and in industrial applications because it is the second best conductor of electricity; also alloyed with zinc or tin to make brass or bronze

_____ b. Used to galvanize iron and steel for protection from rust

_____ c. Used in everything from lawn mower engine blocks to space vehicles because it is lightweight

_____ d. Used primarily as an alloy to toughen steel

_____ e. Used in supersonic aircraft because of its high heat resistance and capacity to withstand vibration; used in petrochemical applications because of its high corrosion resistance

_____ f. Used in the space program because of its light weight and high heat resistance

_____ g. Used for jewelry, coins, and coating electrical devices; usually alloyed with copper or nickel because it is too soft for general use

_____ h. Used in auto batteries and alloyed with tin to make solder

_____ i. Used in coins, jewelry, tableware, and in industrial applications because it is the best conductor of electricity

_____ j. Used for coating tin cans, and used as an alloy to make bronze, babbitt, pewter, and solder

Written Test

Objective 22

Select true statements about guidelines for testing properties of metals by placing an "X" in the blanks next to the true statements.

_____ a. To test for hardness, use a Brinnell hardness tester or a Rockwell tester.

_____ b. To test for weld strength, use a Brinnell tester.

_____ c. To test for impact resistance, use an Izod or a Charpy test with the specimen properly secured for accepting the test load impact.

_____ d. To test for alloys by type and amount, use a Rockwell tester.

Objective 23

Select true statements about equipment requirements for spark testing by placing an "X" in the blanks next to the true statements.

_____ a. Spark testing requires a stationary or portable grinder with a hard-grit grinding wheel.

_____ b. Spark testing requires the use of a grinding wheel or disc with a speed of 5,000 revolutions per minute.

_____ c. Use a clean grinding wheel for spark testing, and use a wire brush if the grinding wheel needs cleaning.

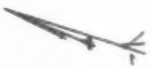
Objective 24

Complete statements about guidelines for spark testing. Circle the material that best completes each of the following statements.

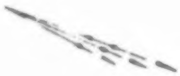
a. Learn to recognize the types of sparks produced by metals you grind.

1. An arrow looks like this:

a.

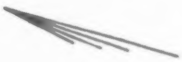


b.

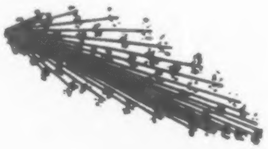


2. A shaft looks like this:

a.

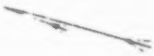


b.

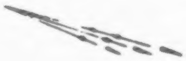


3. A fork looks like this:

a.

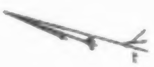


b.

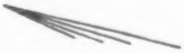


4. A sprig looks like this:

a.

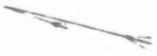


b.

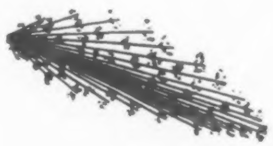


5. A stream looks like this:

a.



b.



b. Look for specific colors as sparks fly from the grinding wheel.

1. A **(red) (yellow)** color usually indicates cast iron.
2. A straw **(green) (yellow)** color at the end of a stream also indicates cast iron.
3. A **(straw) (white)** color usually indicates low- or high-carbon steel.
4. An **(orange) (yellow)** color usually indicates chromium.

c. Evaluate the volume of sparks that fly from the grinding wheel.

1. Nonferrous metals produce **(little or no) (a high volume of)** sparks.
2. Gray cast iron produces a **(medium) (small)** volume, and white cast iron produces a very **(thin) (small)** volume.
3. Low-carbon steel produces a **(large) (moderately large)** volume.
4. High-carbon steel produces a **(moderately large) (large)** volume.
5. Stainless steel produces a **(small to medium) (moderate to large)** volume, depending on the type and amount of alloy in the steel.

d. Note the distance the sparks fly from the grinding wheel.

1. **(Low-carbon) (High-carbon)** steels throw shafts that terminate in forks about 70 inches long.
2. **(Low-carbon) (High-carbon)** steels throw numerous sprigs that look like sparklers about 55 inches long.
3. Stainless and other alloy steels throw shafts and arrows at **(long) (varying)** distances, depending on the type and amount of alloy.

Written Test

Objective 25

Complete statements about characteristics of residual stresses. Circle the material that best completes each of the following statements.

a. Residual stresses are the **(basic elements) (undesirable elements)** of distortion left in a part or an assembly after a welding operation is completed.

b. The forces and counterforces of residual stress can produce **(expansion) (shrinkage)**, fractures, and other forms of distortion that make parts difficult or impossible to fit up.

c. Residual stresses can produce in **(filler metals) (base metals)** structural and metallurgical changes so severe that a welded assembly could fail in service and damage property or injure people.

Objective 26

Select true statements about causes of residual stresses and distortion. Place an "X" beside each true statement.

_____ a. In a welding process, filler metals and base metals expand uniformly in any direction if they are restricted.

_____ b. After a welding procedure, filler metals and base metals contract as they cool, and will assume their original shape if unrestricted.

_____ c. If unrestricted, filler metals and base metals cannot expand or contract uniformly.

_____ d. Residual stresses will vary with joint design, the welding procedure, and metal type and thickness.

_____ e. Welding thick metals promotes residual stresses, and the thicker the metal, the more problems with residual stresses.

Objective 27

Select true statements about guidelines for changing the welding procedure to control stresses. Place an "X" beside each true statement.

_____ a. Modify the joint design.

_____ b. Minimize the heat input by modifying the welding process.

_____ c. Select alternate filler metals or base metals.

_____ d. Peen the weld lightly to help it shrink.

_____ e. Stress relieve by using a postweld heat treatment.

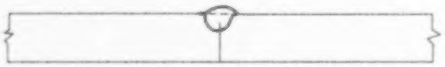
_____ f. Add thermal control by using preheating, interpass heating, postheating, or all three.

_____ g. Add mechanical control by using clamps, wedges, or mechanical fixtures.

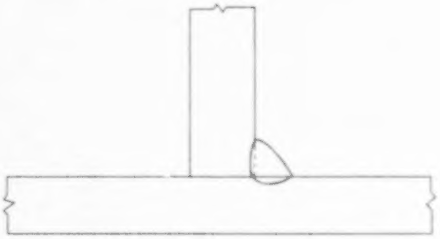
Objective 28

Identify routes for he[illegible]pansion in basic welds. Sketch arrows on the following illustrations to indicate the expansion routes.

a.



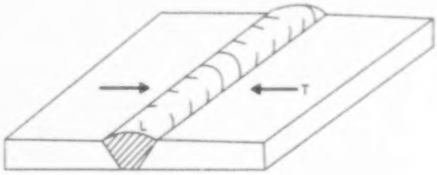
b.



Objective 29

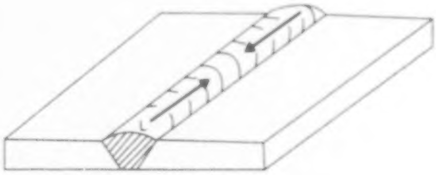
Identify results of longitudinal and transverse stress in basic welds. Circle the number of the item that best describes each of the following illustrations.

a.



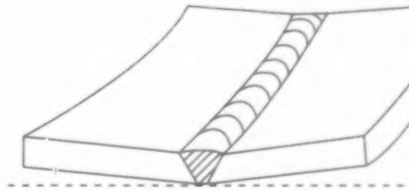
1. Distortion down a butt weld to indicate transverse stress
2. Distortion across a butt weld to indicate transverse stress

b.



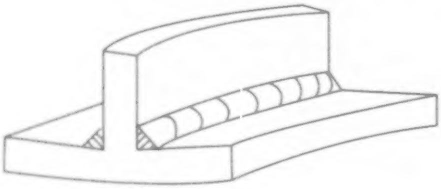
1. Distortion across a butt weld to indicate transverse stress
2. Distortion down a butt weld to indicate longitudinal stress

c.



1. A butt weld with extreme longitudinal stress
2. A butt weld showing the combination of longitudinal and transverse stress

d.



1. A fillet weld showing extreme longitudinal stress
2. A fillet weld showing the effect of longitudinal and transverse stresses in combination

Objective 30

Complete statements about heat applications and their uses in weld quality control. Circle the material that best completes each of the following statements.

a. Preheating a part before a welding process starts can help control cracking, reduce stresses from shrinkage, and promote slower cooling to prevent excessive **(hardening) (distortion)** and brittleness.

b. Heating between welding passes with interpass heat helps maintain the **(required temperature) (filler metal temperature).**

c. Postheating after the welding process ends allows slow cooling which promotes stress relief **(in the weld) (in the weld and the base metal).**

Objective 31

Select true statements about guidelines for preheating in special conditions. Place an "X" beside each true statement.

_____ a. Preheat when welding large or bulky parts or when welding parts with complicated shapes.

_____ b. Preheat when atmospheric temperature is cold or when the temperature of the part is cold.

_____ c. Preheat when the carbon or alloy content of steel is low.

_____ d. Preheat when a slow welding speed is specified.

Objective 32

Complete statements about methods of preheating and postheating and their applications. Circle the material that best completes each of the following statements.

a. Preheat and postheat **(odd-shaped) (small)** parts in a furnace.

b. Preheat and postheat **(long) (bulky)** parts by using acetylene, propane, or oil torches in banks of two or more.

c. Preheat and postheat **(bulky) (long or wide)** parts with electrical strip heaters clamped parallel to joints, about 6" from the seam.

d. For **(low-carbon steel) (general service)** preheating and postheating, use a natural gas torch with compressed air and a single-orifice heating tip.

e. When preheating or postheating with a torch, use a heating tip **(the same size as) (one size larger than)** the tip required to oxyacetylene weld the joint.

f. For torch heating **(steel rails) (large parts)**, use a torch with a multiflame head or rosebud.

Objective 33

Match torch preheating techniques with their applications. Place the number of the technique in the blank beside the appropriate application.

1. Slot heating 2. Convex heating 3. Spot heating

_____ a. Applying heat at one specific point so that cooling will cause a slight inward movement around the joint and help control nondirectional distortion

_____ b. Applying heat along a seam or perpendicular to a seam to control direction distortion

_____ c. Applying heat along a side to shorten it, or applying other heating techniques to a certain side of a plate in order to flatten it

Objective 34

Match types of steels with their recommended preheat temperatures. Place the number of the steel in the blank beside the appropriate preheat temperature.

1. Medium-carbon steels 2. Mild steels 3. High-carbon steels

_____ a. Preheating is not normally required, but if temperature is below 50°F, preheat to about 100°F or higher, if the plate thickness is over 1".

_____ b. Preheat from 200°F to 400°F, retain the same interpass temperature, and postheat is recommended, especially on thicker metals.

_____ c. Preheat and interpass temperatures should be a minimum of 400°F, and postheat is recommended, especially on thicker metals.

Written Test

Objective 35

Match temperature-sensing devices with their uses. Place the number of the device in the blank beside the appropriate use.

1. Crayons and pellets
2. Pyrometers
3. Thermocouples

_____ a. Portable thermometers used to measure surface heat

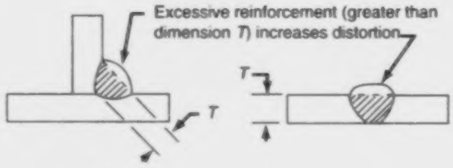
_____ b. Temperature-sensing devices that may be attached to the work, but more often are used in heating ovens or postweld heat treatment processes

_____ c. Temperature-sensing devices available in different degrees; can be used to indicate localized temperature; may be used in pairs to indicate a high and low temperature range

Objective 36

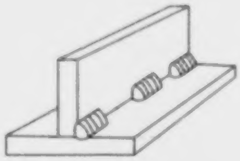
Identify methods for controlling distortion with the welding process. Circle the number of the information that best describes the type of distortion control in the following illustrations.

a.


Excessive reinforcement (greater than dimension T) increases distortion

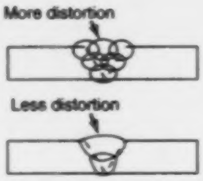
1. Use as few passes as specifications permit.
2. Do not overweld.
3. Place welds along a neutral axis.

b.



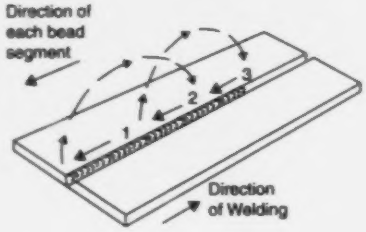
1. Use intermittent welds.
2. Use backstep welding.
3. Do not overweld.

c.


More distortion
Less distortion

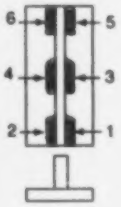
1. Use as few passes as specifications permit.
2. Do not overweld.
3. Use intermittent welds.

d.


Direction of each bead segment
1
2
3
Direction of Welding

1. Use backstep welding.
2. Use as few passes as specifications permit.
3. Use intermittent welds.

e.



1. Weld in an alternating sequence.
2. Use backstep welding.
3. Use intermittent welds.

Written Test

Objective 37

Select true statements about guidelines for controlling distortion with mechanical means. Place an "X" beside each true statement.

_____ a. Modify the edge preparation, especially on thicker metals; decrease the bevel angle and increase the root opening, or use a J- or U-joint design.

_____ b. Use a single V-joint in place of a double V-joint because the single joint requires about half the weld metal for the same plate thickness.

_____ c. Anticipate the places and amount of shrinkage and preset parts so that shrinkage forces will pull them into alignment during welding.

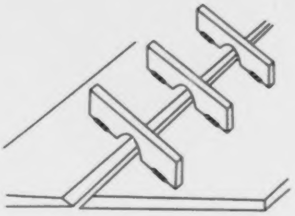
_____ d. Prebend and clamp parts to make the joint longer so that shrinkage will cause the joint to lie flat as the plate cools and the clamps are removed.

_____ e. Clamp parts front to back, if possible, to help distortion forces work with each other for shrinkage control.

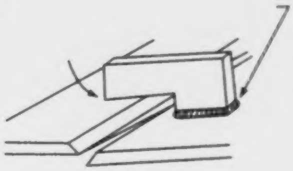
Objective 38

Match methods for controlling distortion with restraining devices with their application. Place the number of the illustration in the blank beside the appropriate application.

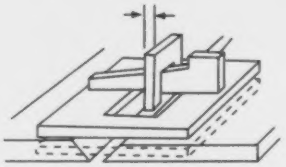
1.



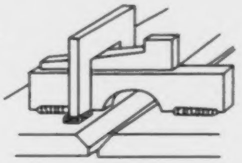
2.



3.



4.



_____ a. When welding butt plates, tack weld clips along the edges of one plate, then drive wedges under the open side of the clips to force the edges into alignment.

_____ b. For aligning plates, tack weld a yoke to a backup strip, slip the yoke between the edges, then place a yoke guide on top of the plates and drive a wedge through the first yoke to complete alignment.

_____ c. For butt welds on thicker plates, tack weld a yoke on top of one plate, tack weld a bar to the top of the second plate, then drive a wedge between the yoke and the bar to complete alignment.

_____ d. Several strongbacks together could restrain a weld so much that the weld could crack as it cools, so when several strongbacks are required, position them at a 45° angle across the joint to allow for transverse movement.

Answers to Written Test

Objective 1

a. 3
b. 7
c. 9
d. 11
e. 4
f. 1
g. 2
h. 6
i. 8
j. 12
k. 10
l. 5

Objective 2

b

Objective 3

a. 3
b. 6
c. 5
d. 2
e. 7
f. 1
g. 4

Objective 4

a, b, c, f

Objective 5

a. 2
b. 4
c. 6
d. 8
e. 10
f. 9
g. 7
h. 5
i. 3
j. 1

Objective 6

a. 2
b. 4
c. 1
d. 3

Objective 7

a, b, e

Objective 8

a. 2
b. 2
c. 2

Objective 9

a. 2
b. 4
c. 1
d. 3

Objective 10

a. 3
b. 4
c. 1
d. 2
e. 6
f. 5

Answers to Written Test

Objective 11

a. 4
b. 6
c. 2
d. 10
e. 8
f. 12
g. 11
h. 1
i. 7
j. 3
k. 5
l. 9

Objective 12

a. 2
b. 4
c. 1
d. 3

Objective 13

a. Rust
b. Dull metallic
c. Some
d. In almost any environment
e. Rapidly
f. Has high corrosion resistance
g. Resists corrosion, but it will tarnish
h. Resists corrosion

Objective 14

b, d, e, f

Objective 15

a. 1. 99%
   2. Copper
   3. Manganese
   4. Silicon
   5. Magnesium
   6. Silicon and magnesium in approximate proportions
   7. Zinc

b. Four-digit; four-digit

Objective 16

b

Objective 17

a, b

Objective 18

a. 3
b. 2

Objective 19

a. Aircraft
b. Commercial
c. High tensile

Objective 20

a. 3
b. 5
c. 1
d. 4
e. 2

Answers to Written Test

Objective 21

a. 5
b. 7
c. 9
d. 1
e. 3
f. 8
g. 6
h. 10
i. 2
j. 4

Objective 22

a, c

Objective 23

c

Objective 24

a.
  1. b
  2. a
  3. a
  4. a
  5. b

b.
  1. Red
  2. Yellow
  3. White
  4. Orange

c.
  1. Little or no
  2. Small; small
  3. Moderately large
  4. Large
  5. Moderate to large

d.
  1. Low-carbon
  2. High-carbon
  3. Varying

Objective 25

a. Undesirable elements
b. Shrinkage
c. Base metals

Objective 26

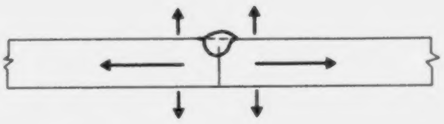
b, d, e

Objective 27

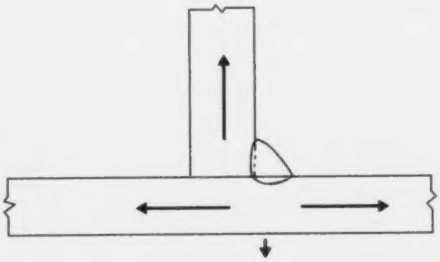
a, b, c, e, f, g

Objective 28

a.



b.



Answers to Written Test

Objective 29	a. 2 b. 2 c. 2 d. 2
Objective 30	a. Hardening b. Required temperature c. In the weld and the base metal
Objective 31	a, b
Objective 32	a. Small b. Bulky c. Long or wide d. General service e. The same size as f. Large parts
Objective 33	a. 3 b. 1 c. 2
Objective 34	a. 2 b. 1 c. 3
Objective 35	a. 2 b. 3 c. 1
Objective 36	a. 2 b. 1 c. 1 d. 1 e. 1
Objective 37	a, c, d
Objective 38	a. 2 b. 3 c. 4 d. 1

Teacher Supplement 1—Heating Ranges of Ferrous Metals

The heating ranges for steels with different carbon content reveal significant information about the reaction of no-carbon steels to heat. Use the following information along with Transparency 4 to introduce students to heat ranges. Relate heat changes to specific changes in characteristics of steel at varying temperatures so students will gain the basics of a metallurgical approach to metals.

Start at the bottom of the transparency with the sub-zero temperature range. Point out to students the extent of the range, from 0°F to minus 300°F. The significant changes in almost all metals in the sub-zero range is that they show a decrease in impact resistance. In fact, the lower the temperature, the lower the impact resistance.

Now as you move up the heat range chart to the color-coded heat ranges—black heat range, red heat range, white heat range—note that the color-coded ranges are based on steel with zero percent carbon. The rule of thumb for using the chart for other steels is: as carbon content in steel increases, preheating temperatures increase and temperatures above the transformation range decrease. With that rule of thumb in mind, you should be able to use steel samples from your own shop to demonstrate temperature ranges.

Start with the black heat range which extends from 0°F to 1000°F. The black heat range includes the preheating range for welding, a range which runs from about 60°F to just above 700°F. Note that the black heat range includes the blue brittle range from 300°F to 700°F. The blue brittle is the range where peening or working of steels should not be attempted. Metals are more brittle at the blue brittle range than they are above or below the blue brittle range. Note too that the black heat range includes the nitriding range from about 950°F to 1000°F. In manufacturing, certain steels are subjected to ammonia gas for long periods to give them extremely hard surfaces as the metals absorb nitrogen.

The red heat range extends from 1000°F to 2050°F. The red heat range includes the stress relieving range which runs from about 1120°F to 1250°F. Stress relief means the metal is held at the stress relieving range long enough to relieve locked-up stresses. Then, the metal is cooled slowly to produce what is called "process annealing."

The spheroidizing range is also in the red heat range. When a metal is held long enough at a temperature between 1250°F and 1350°F, it becomes soft enough to provide good machinability. This is accomplished in the spheroidizing range.

The range from 1350°F to 1690°F is called the transformation range. In the transformation range, steels undergo radical changes which affect their properties.

Teacher Supplement 1

Austenite steel is produced in the annealing and normalizing range that extends from 1400°F to 1750°F. When steels are held at this temperature long enough, then slowly cooled, it produces a steel that has small grain size, softness, and good ductility.

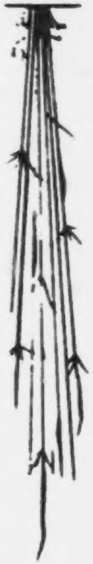
The carburizing range extends from about 1600°F to 1810°F. In this range, carbon can be dissolved into the surface of steel to create hard, high-carbon steel.

The forging range extends from 1810°F to 2400°F. Temperatures in the forging range permit metals to be mechanically worked or fused together.

Heating ranges play a significant role in metal manufacturing. A knowledge of heating ranges is a valuable asset for welders because heat and its proper application can help control distortion and produce a quality product.

Spark Test Characteristics

Low-Carbon Steel



Color-white

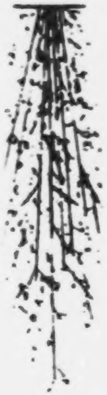
Average length of stream with power grinder - 70 in.

Volume -moderately large

Shafts shorter than wrought iron and in forks and appendages

Forks become more numerous and sprigs appear as carbon content increases

High-Carbon Steel



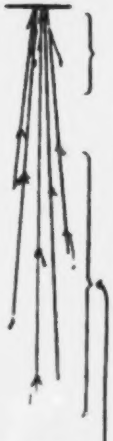
Color -white

Average stream length with power grinder - 55 in.

Volume -large

Numerous small and repeating sprigs

Stainless and Other Alloy Steel



Color -straw yellow

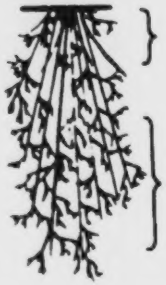
Stream length varies with type and amount of alloy content

Shafts may end in forks, buds or arrows, frequently with break between shaft and arrow. Few, if any, sprigs

Color - white

Spark Test Characteristics (continued)

White Cast Iron



Color - red

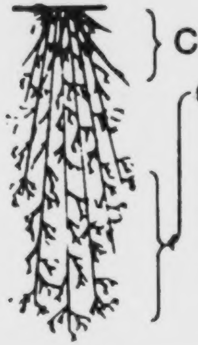
Color -straw yellow

Average stream length with power grinder - 20 in.

Volume -very small

Sprigs -finer than gray iron, small and repeating

Gray Cast Iron



Color - red

Color -straw yellow

Average stream length with power grinder - 25 in.

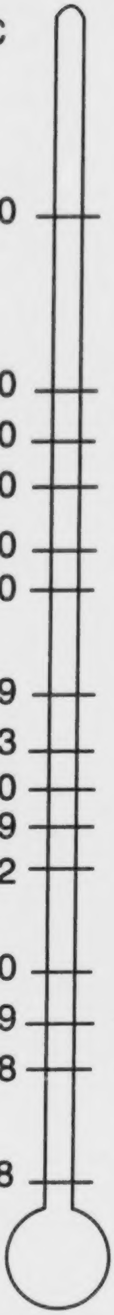
Volume -small

Many sprigs, small and repeating

205

204

Metal Melting Points and Other Temperatures



°C	°F	
6020	10,900	Welding arc
3500	6330	Oxyacetylene flame
3410	6170	Tungsten melts
2800	5070	Oxyhydrogen flame
1890	3430	Chromium melts
1870	3360	Natural gas burner
1539	2802	Iron melts
1083	1981	Copper melts
660	1220	Aluminum melts
419	787	Zinc melts
232	449	Tin melts
0	32	Ice melts
—39	—38	Mercury melts
—78	—110	Dry ice vaporizes
—273.18	—459.72	Absolute zero

Aluminum Hardness and Tempering Designations

T#	Process	Applications
T1	Naturally aged to a substantially stable condition	Castings which have their strength increased by room-temperature aging from the as-cast condition
T2	Annealed cast products only	Casting which have their ductility improved and dimensional stability increased with an annealing treatment
T3	Solution heat-treated and then cold worked	Products cold worked to improve strength or to achieve the effect of cold work in flattening or straightening
T4	Solution heat-treated and naturally aged to a substantially stable condition	Products which are not cold worked after solution heat-treatment
T5	Artificially aged from the as-cast condition	Products which are aged at elevated temperatures from the as-cast condition to improve mechanical properties or dimensional stability or both
T6	Solution heat-treated and then artificially aged	Products which are not cold worked after solution heat-treatment
T7	Solution heat-treated and then stabilized	Products which are stabilized to carry them beyond the point of maximum strength to provide control of special characteristics
T8	Solution heat-treated, cold worked, then artificially aged	Products which are cold worked to improve strength for certain applications
T9	Solution heat-treated, artificially aged, and then cold worked	Products which are cold worked to improve strength for certain applications
T10	Artificially aged and then cold worked	Products which are artificially aged after an elevated-temperature, rapid-cool process, and then cold worked to improve strength

Unit 6 Basic Math and Measuring

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*Job Sheets

1—Adjust a Bevel Square to a 45° Angle Using a Framing Square, a Combination Square, and a Protractor 99
2—Form 90° and 45° Angles with a Combination Square and Draw Parallel Lines on Metal Stock 103

*Assignment and Job Sheets are located in the Student Workbook.

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make copies of any teacher supplements that will be provided for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

  TM 1—Decimal Equivalent Chart (Objective 3)
  TM 2—Inches-to-Decimal Conversion Chart (Objective 4)
  TM 3—Graduations on a Rule (Objective 6)
  TM 4—Graduations on a Rule (continued) (Objective 6)
  TM 5—Reading Fourths on a Rule (Objective 7)
  TM 6—Reading Eighths on a Rule (Objective 7)
  TM 7—Reading Sixteenths on a Rule (Objective 7)
  TM 8—Reading Measurements on a Metric Rule (Objective 7)

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Suggested Activities

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.
- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Pay particular attention to students who have weak math skills. Arrange to spend extra time with students who have problems with basic math. Pair them up with students who have good math skills so they will not feel they are being singled out.
- Be sure to have a bevel square, a framing square, a combination square, and a protractor available for use with job sheets 1 and 2. Students need to master the use of a bevel square because they will be required to use it for measuring bevels on groove welds when they begin shielded metal arc welding.
- Assignment Sheet 13 presents some basics in the use of an English-metric conversion chart. Several other conversion groups are presented in Teacher Supplement 1. Prepare additional problems for students as you see fit. Conversions of velocity and temperature should be especially useful.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.

- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.

- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

  Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

  Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

  Sample A

  4—**Skilled**—Can perform job with no additional training.
  3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
  2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
  1—**Unskilled**—Is familiar with process, but is unable to perform job.
  0—**No exposure**—No information or practice provided during training program.

  Sample B

  Yes—Can perform job with no additional training.
  No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.

- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.

- Reteach and retest as required.

Suggested Activities

Resources Used in Developing This Unit

Print Media

- Carmen, Robert A. and Hal M. Saunders. *Mathematics for the Trades.* New York: John Wiley & Sons, 1986.
- Fortney, Clarence and Mike Gregory. *Introduction to Welding.* Stillwater, OK: MidAmerica Vocational Curriculum Consortium, 1984.
- Olivo and Olivo. *Basic Vocational-Technical Mathematics.* Albany, NY: Delmar Publishers inc., 1985.
- Olivo and Olivo. *Basic Vocational-Technical Mathematics Fundamentals.* Albany, NY: Delmar Publishers Inc., 1985.
- St. Paul Area Technical Institute. *Mathematics for Careers: Fractions.* Albany, NY: Delmar Publishers, 1981.
- St. Paul Area Technical Institute. *Mathematics for Careers: Measurement and Geometry.* Albany, NY: Delmar Publishers, 1981.
- St. Paul Area Technical Institute. *Mathematics for Careers: Multiplying and Dividing Whole Numbers.* Albany, NY: Delmar Publishers, 1981.

Suggested Supplemental Resources

Print Media

- Schell, Frank R., and Bill Matlock. *Practical Problems in Mathematics for Welders*, Fourth Edition. Albany, NY: Delmar Publishing Company, 1995.

  This book may be ordered online from Delmar Publishing at www.delmar.com, or call (800) 347-7707.

- Marion, Nino. *Math for Welders.* Tinley Park IL: Goodheart-Willcox Publishing, 1996.

  This book may be ordered online from Goodheart-Willcox publishing at www.goodheartwillcox.com, or call (800) 323-0440.

  See Unit 4, Fundamentals of Welding for ordering information on publications and videos from the L.S. Starrett Company pertaining to precision measuring tools and how to use them.

Electronic Media

Videotapes:

- Basic Math: Fractions and Decimals—set of five videos

  Written specifically for vocational applications, this program is based on technical mathematics and focuses on practical applications.

- Reading a Ruler—set of two videos

  Describes the two common systems of linear measurement: The Customary System, and The Metric System.

  Order the preceding videos online from Bergwall at www.bergwall.com, or call (800) 645-3565.

Internet:

- www.starrett.com - L.S. Starrett Company—provides technical information on precision measuring
- www.math.com - Excellent source for instructional materials; allows students to practice math skills
- www.sosmath.com - Excellent internet site for practicing basic math, fractions, decimals, and percentages
- www.funbrain.com - Practice fractions using fun math games

Answers to Assignment Sheets

Assignment Sheet 1

Add, Subtract, Multiply, and Divide Fractions

6 a. 1. $1^{1}/_{4}$
2. $2^{3}/_{32}$
3. $12^{1}/_{4}$
b. 1. $^{1}/_{8}$
2. $^{13}/_{16}$
3. $1^{13}/_{16}$
c. 1. $^{15}/_{32}$
2. $21^{1}/_{4}$
d. 1. 2
2. $^{1}/_{2}$

Assignment Sheet 2

Add, Subtract, Multiply, and Divide Decimal Equivalents

6 a. 1. 17.6833
2. 8.86632
3. 25.7563
b. 1. 8.722
2. .154
3. 8.875
c. 1. 1.6405 or 1.640496
2. 81.7494 or 81.749430
d. 1. .0024
2. 3.04833

Assignment Sheet 3

Convert Fractions to Decimal Form, Change Fractions to a Common Denominator, and Reduce Fractions to Lowest Terms

4 a. 1. 1 ÷ 2 = .500
2. 5 ÷ 8 = .625
3. 1 ÷ 4 = .250
4. 1 ÷ 8 = .125
5. 5 ÷ 16 = .3125
6. 9 ÷ 16 = .5625
7. 3 ÷ 4 = .750
8. 7 ÷ 8 = .875
9. 3 ÷ 8 = .375
10. 11 ÷ 16 = .6875
b. 1. $^{3}/_{8}$
2. $^{19}/_{32}$
3. $2^{23}/_{32}$
4. $^{7}/_{64}$
5. $1^{54}/_{64}$ or $1^{27}/_{32}$

Answers to Assignment Sheets

c.
1. $^{3}/_{4}$
2. $^{2}/_{3}$
3. $^{3}/_{4}$
4. $^{1}/_{3}$
5. $^{11}/_{32}$
6. $^{9}/_{16}$
7. $1\,^{7}/_{56}$
8. $^{5}/_{8}$
9. $1\,^{3}/_{16}$
10. $^{3}/_{4}$

Assignment Sheet 4

Write Fractions as Decimals and Percents

3 a.
1. .125
2. .25
3. .50
4. .75
5. .625
6. .35
7. .4375
8. .1111--
9. .444--
10. .80

b.
1. 25%
2. 22.22% or $22\,^{2}/_{9}$%
3. 70%
4. 75%
5. 100%
6. 81.81% or $81\,^{9}/_{11}$%
7. 33.33% or $33\,^{1}/_{3}$%
8. 44.44% or $44\,^{4}/_{9}$%
9. 33.33% or $33\,^{1}/_{3}$%
10. 62.5% or $62\,^{1}/_{2}$%

Assignment Sheet 5

Write Percents as Fractions and Decimals

3 a.
1. $^{1}/_{2}$
2. $^{1}/_{4}$
3. $^{1}/_{3}$
4. $^{9}/_{25}$
5. $^{7}/_{25}$
6. $^{1}/_{7}$
7. $^{21}/_{100}$
8. $^{9}/_{20}$
9. $^{2}/_{3}$
10. $^{7}/_{10}$

b. 1. .47
2. .15
3. .333
4. .62
5. .75
6. .03
7. .168
8. .09
9. .10
10. .50

Assignment Sheet 6

Write Decimals as Fractions and Percents

3 a. 1. 1/2
2. 4/5
3. 7/10
4. 1/4
5. 17/25
6. 11/20
7. 47/50
8. 3/8
9. 7/8
10. 53/250
b. 1. 12%
2. 19%
3. 70%
4. 29%
5. 37%
6. 42%
7. 50%
8. 52.3%
9. 74.6%
10. 375%

Assignment Sheet 7

Make Conversions with a Decimal Equivalent Chart

5 a. 1. .0625
2. .875
3. .25
4. .5
5. .5625
b. 1. 7/16
2. 5/16
3. 3/8
4. 1/8
5. 11/16

Answers to Assignment Sheets

Assignment Sheet 8

Make Conversions with an Inches-to-Decimal Conversion Chart

3 a. 1. 9.56′ or 9.5625′
  2. 3.38′ or 3.3854′
  3. 14.19′ or 14.1875′
  4. 1.5′
 b. 1. 2′ 6″
  2. 8′ $7^{3}/_{5}$″
  3. 11′ $8^{9}/_{10}$″
  4. 17′ $1^{7}/_{20}$″

Assignment Sheet 9

Measure Distance with 1″, $^{1}/_{2}$″, and $^{1}/_{4}$″ Graduations

1. a. 4
   b. No
   c. No
   d. 4
   e. No

2. a. No
   b. 5 inches
   c. No
   d. Nearest unit

3. a. 1 inch
   b. 4 inches
   c. 3 inches
   d. Approximate

4. a. No
   b. Yes

5. a. 2
   b. $2^{1}/_{2}$ inches

6. $^{1}/_{2}$, $2^{1}/_{2}$, $3^{1}/_{2}$, $4^{1}/_{2}$

7. a. $2^{1}/_{2}$
   b. $2^{1}/_{2}$ inches

8. a. 4 inches
   b. 4 inches
   c. 1 inch
   d. No

9. a. $3^{1}/_{2}$ inches
   b. 5 inches
   c. $1^{1}/_{2}$ inches

10. a. 1/4
    b. 4

11. 1 1/2 , 2 1/4, 2 3/4, 3 1/4, 3 1/2, 4 3/4

Assignment Sheet 10

Measure Distances with 1/4" and 1/8" Graduations

1. a. 5 3/4
   b. 1/2
   c. 1 1/2
   d. 7 1/4
   e. 3 1/4

2. a. 2 1/2
   b. 1 3/4
   c. 3
   d. 7 7/8
   e. 3 3/16 (already in simplest form)

3. a. 3/4 inch
   b. 1 1/4 inches
   c. 2 inches
   d. 2 1/2 inches
   e. 3 1/4 inches
   f. 4 3/4 inches

4. a. 4 inches
   b. 1/2 inch
   c. 4 3/4 inches
   d. 2 1/4 inches

5. E

6. a. 8
   b. 2
   c. 16
   d. 4
   e. Half
   f. Fourth
   g. 2
   h. 4

7. a. 8
   b. Eighths
   c. 8

Answers to Assignment Sheets

8. a. $4^{7}/_{8}$
   b. $^{1}/_{8}$
   c. 3
   d. $1^{1}/_{8}$
   e. $2^{3}/_{8}$

9. $^{1}/_{8}$, $^{4}/_{8}$, $^{5}/_{8}$, $^{8}/_{8}$

10. a. $3^{2}/_{4} = 3^{4}/_{8}$
    b. $2^{2}/_{8}$
    c. $3^{6}/_{8}$

11. a. $2^{2}/_{4}$
    b. $2^{4}/_{8}$

Assignment Sheet 11

Measure Distances with $^{1}/_{8}$" Graduations

1. a. $^{1}/_{8}$ inch
   b. $^{1}/_{2}$ inch
   c. $^{3}/_{4}$ inch
   d. $1^{1}/_{4}$ inches
   e. $1^{5}/_{8}$ inches
   f. $1^{7}/_{8}$ inches
   g. $2^{3}/_{8}$ inches
   h. 3 inches
   i. $3^{1}/_{2}$ inches
   j. $3^{3}/_{4}$ inches
   k. $4^{1}/_{8}$ inches
   l. $4^{5}/_{8}$ inches
   m. $5^{1}/_{4}$ inches
   n. $5^{5}/_{8}$ inches

2. a. $1^{1}/_{8}$ inches
   b. $^{3}/_{8}$ inch
   c. $^{5}/_{8}$ inch
   d. $^{1}/_{4}$ inch
   e. $2^{1}/_{2}$ inches
   f. 3 inches
   g. $1^{1}/_{8}$ inches
   h. $^{1}/_{4}$ inch
   i. $^{1}/_{2}$ inch
   j. $2^{1}/_{4}$ inch

Assignment Sheet 12

Measure Distances with $^{1}/_{16}$" Graduations

1. a. 16
   b. $^{1}/_{16}$
   c. 16, 8
   d. $^{1}/_{16}$ inch
   e. $3^{1}/_{16}$ inch

2. a. 2
   b. 8
   c. 1
   d. 4
   e. 16

3 a. 16
   b. Sixteenth
   c. 16
   d. 8

4. a. Yes
   b. No
   c. Yes
   d. Yes
   e. No
   f. Yes
   g. No

5. a. $^{1}/_{16}$, $^{5}/_{16}$, $^{7}/_{16}$, $^{9}/_{16}$, $^{11}/_{16}$, $^{15}/_{16}$
   b. $3^{4}/_{8}$, $3^{2}/_{4}$, $3^{1}/_{2}$

6. a. $^{1}/_{8}$
   b. $^{3}/_{4}$ and $^{6}/_{8}$
   c. $^{2}/_{2}$, $^{4}/_{4}$, $^{8}/_{8}$, $^{16}/_{16}$
   d. $^{3}/_{8}$
   e. $^{5}/_{8}$
   f. $^{3}/_{4}$
   g. Zero
   h. Yes

7. a. 16ths
   b. $^{5}/_{16}$
   c. $^{5}/_{16}$
   d. $3^{5}/_{16}$ inches
   e. $4^{5}/_{16}$ inches

Answers to Assignment Sheets

8. a. $1^{9}/_{16}$ inches
   b. $2^{7}/_{8}$ inches
   c. $3^{1}/_{2}$ inches
   d. $4^{3}/_{16}$ inches

9. a. 2 inches
   b. 2 inches
   c. $1^{3}/_{4}$ inches
   d. $1^{7}/_{8}$ inches
   e. $1^{13}/_{16}$ inches
   f. E

Assignment Sheet 13

Make Conversions with an English-Metric Conversion Chart

1. 0.4765625 centimeters
2. 4.88 meters
3. 6.6 pounds
4. 39.6 pounds

Assignment Sheet 14

Calculate Area of Geometric Figures

a. 1. 64 square inches
   2. 256 square feet
   3. 225 square feet
   4. 1,296 square yards
b. 1. 60 square feet
   2. 192 square yards
   3. 527 square inches
   4. 992 square feet
c. 1. 113.04 square inches
   2. 615.44 square feet
   3. 803.84 square feet
   4. 490.625 square yards
d. 1. 48 square inches
   2. 199.5 square feet
   3. 19.5 square inches
   4. 180 square yards
e. 1. 12 square feet
   2. 104 square yards
   3. 256 square inches
   4. 243 square yards
f. 1. 493 square inches
   2. 242 square yards
   3. 168 square feet
   4. 765 square yards

Written Test

Name ____

Date ______________________________ Score__________

Objective 1

Match terms related to basic math and measuring with their correct definitions.

1. H or h
2. P or p
3. Sublinear numbers
4. B or b
5. Graduations
6. Pi or π
7. A or a
8. Superlinear numbers
9. Cubic measure
10. Metric System
11. L or l
12. English System
13. Square measure

_____ a. Area, the measurement of surface inside a figure

_____ b. Base

_____ c. The measurement of volume

_____ d. A system of measurement based on feet and pounds

_____ e. Subdivisions on a measuring device

_____ f. Height

_____ g. Length

_____ h. A system of measurement based on meters and kilograms

_____ i. Perimeter, the distance around a flat surface

_____ j. A letter from the Greek alphabet used to indicate the ratio of the circumference of a circle to its diameter

_____ k. The measurement of area

_____ l. Numbers which appear below a line to clarify a reference

_____ m. Numbers which appear about a line to indicate the degree of increase in power

Written Test

Objective 2

Match basic mathematical terms with their definitions.

1. Denominator
2. Complex fraction
3. Factors
4. Whole number
5. Proper fraction
6. Sum
7. Fraction
8. Common denominator
9. Mixed number
10. Quotient
11. Numerator
12. Improper fraction
13. Lowest terms
14. Unit fraction

_____ a. Any number or numbers used to indicate an entire unit, quantity, or amount

_____ b. Two numbers consisting of a numerator and denominator separated by a fraction line to indicate a part of one unit

_____ c. Any whole number plus a fractional part of one additional unit

_____ d. The top number of a fraction

_____ e. The bottom number of a fraction

_____ f. A fraction whose numerator is less than the denominator, indicating a value of less than one unit

_____ g. A fraction whose numerator is equal to or greater than the denominator, indicating a value greater than one unit

_____ h. A proper fraction with a numerator of 1

_____ i. A fraction with either or both terms expressed as a fraction or mixed number

_____ j. The lowest base number (numerator and denominator) by which a fraction may be reduced for simplification in unit measurement

_____ k. Two fractions with the same denominator in each fraction

_____ l. The parts of a number that can be multiplied to equal that number

_____ m. The result of addition

_____ n. The result of division

Objective 3

Complete statements about benefits of decimal equivalent charts. Circle the material that best completes each statement.

a. Decimal equivalent charts provide a (**scientific way**) (**quick reference**) for converting fractions to decimals.

b. Converting fractions to decimals provides (**faster time**) (**greater accuracy**) in measuring.

c. The decimal equivalent chart is also handy for converting (**decimals into fractions**) (**feet into inches**), if the information is required.

Objective 4

Select true statements about benefits of an inches-to-decimal conversion chart. Place an "X" beside each true statement.

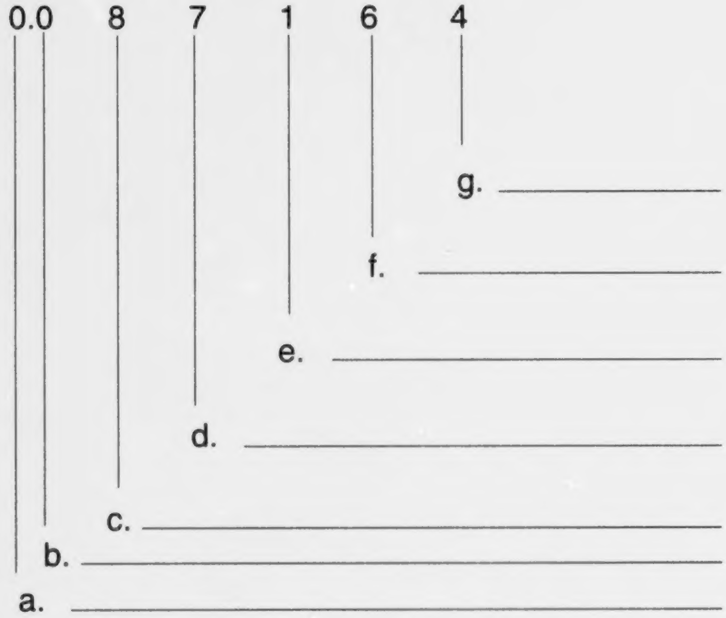
_____ a. Converting inches on a rule into decimal form is much slower when you use an inches-to-decimal chart, but it is much more accurate.

_____ b. An inches-to-decimal conversion chart provides an easy reference for adding, subtracting, multiplying, and dividing parts of a linear measurement.

_____ c. An inches-to-decimal conversion chart can also be used for finding feet and inches by simple subtraction.

Objective 5

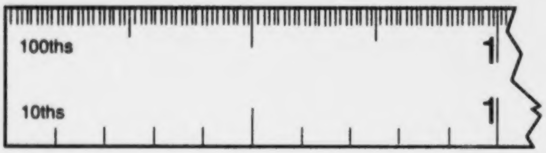
Label the place values in the decimal number below.



Objective 6

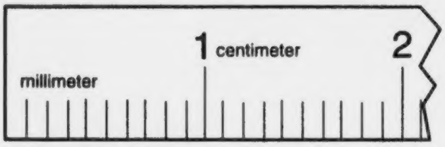
Identify types of rules and list at least two examples of their graduations.

a. Rule name ______________________________


100ths
1
10ths
1

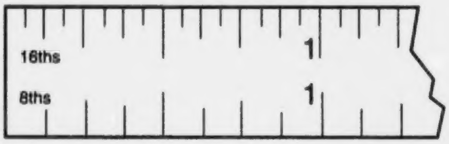
Graduations: ______________________________

b. Rule name ______________________________


1
centimeter
2
millimeter

Graduations: ______________________________

c. Rule name ______________________________


16ths
1
8ths
1

Graduations: ______________________________

Objective 7

Arrange in order the steps in reading a rule. Place a "1" beside the first step, a "2" by the second step, and place the other steps in order.

_____ a. Total the number of graduations.

_____ b. Count whole units.

_____ c. Reduce graduations to lowest terms.

_____ d. Select proper scale.

Objective 8

Match terms used in geometry with their definitions. Write the correct numbers in the blanks.

1. Perimeter
2. Radius
3. Volume
4. Lineal
5. Parallel
6. Diameter
7. Geometric figure
8. Area
9. Cubic foot
10. Circumference
11. Cubic unit
12. Right angle
13. Pi
14. Perpendicular

_____ a. Volume of an object that is 1 foot long, 1 foot wide, and 1 foot high

_____ b. Shape formed by straight or curved lines

_____ c. Line or surface at a right angle to another line or surface

_____ d. Outer limits of boundary

_____ e. Greek letter (π) representing the ratio of a circle's circumference to its diameter; the ratio is approximately 3.1416

_____ f. Distance around the outer edge of circle

_____ g. Distance between the outer edges of a circle through its center point

_____ h. Measure of a flat surface; expressed in square units

_____ i. Line from the center of a circle to any point on the edge of a circle

_____ j. Relating to, consisting of, or resembling a straight line

_____ k. Line or surface extending in the same direction, an equal distance apart and never meeting

_____ l. Space occupied by a body; expressed in cubic units

_____ m. Angle formed by two lines perpendicular to each other; a 90-degree angle

_____ n. Unit with three equal dimensions including length, width, and height

Objective 9

Match types of geometric figures with their descriptions. Write the correct numbers in the blanks. Descriptions continue on the next page.

1. Circle
2. Parallelogram
3. Trapezoid
4. Triangle
5. Rectangle
6. Rhombus
7. Square

_____ a. Figure having three sides and three angles

_____ b. Figure having four sides of equal length and four right angles

_____ c. Flat, round figure formed by one curved line, all points of which are an equal distance from the center point

_____ d. Figure having no right angles and four sides of equal length

_____ e. Figure with only one pair of parallel opposite sides

_____ f. Figure with two parallel ends of equal length, two parallel sides of equal length, and four right angles

_____ g. Figure such as a square, rectangle, or rhombus with two parallel ends of equal length and two parallel sides of equal length

Objective 10

Match units of measure to their equivalents. Write the correct numbers in the blanks.

1. Inch (″)
2. Foot (′)
3. Yard
4. Rod
5. Mile
6. Degree (°)

_____ a. Equal to five thousand, two hundred and eighty feet (5,280′)

_____ b. Equal to one-twelfth of a foot ($^1/_{12}$′) or one thirty-sixth of a yard ($^1/_{36}$ yard)

_____ c. Equal to three feet (3′) or thirty-six inches (36″)

_____ d. Equal to $^1/_{360}$ of a circle

_____ e. Equal to sixteen and one-half feet (16 $^1/_2$′)

_____ f. Equal to twelve inches (12″) or one third of a yard ($^1/_3$ yard)

Objective 11

Match squares, rectangles, and triangles with formulas for calculating their perimeters. Place the number of the figure in the blank beside the appropriate formula.

1. Rectangle
2. Square
3. Triangle

_____ a. $P = 4s$

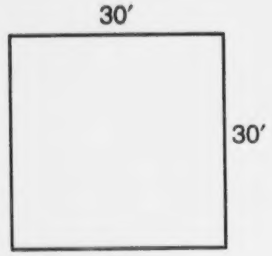
_____ b. $P = 2L + 2W$

_____ c. $P = s_1 + s_2 + s_3$

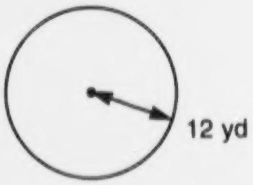
Objective 12

Calculate area of the following geometric figures. Show your work and write the correct answers in the blanks.

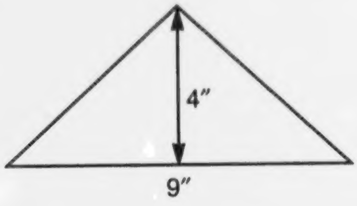
__________ a.



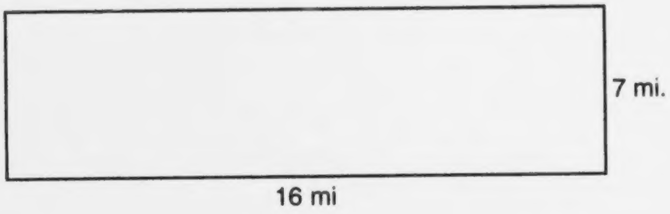
__________ b.



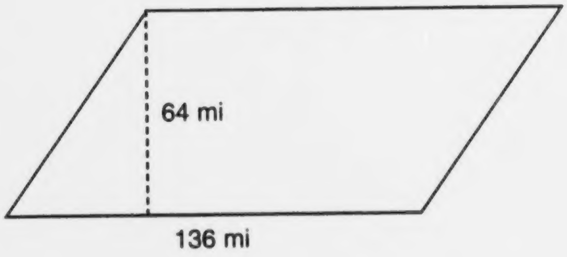
__________ c.



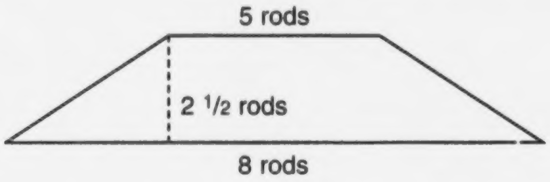
__________ d.



__________ e.



_____ f.



Objective 13

Solve problems about English-Metric conversion charts and how to use them. Write the correct numbers in the blanks.

_____ a. If you knew that the conversion factors were 25.4 and you wanted to convert 12 inches to millimeters, you should:

1. Divide 25.4 by 12 to get 2.1 millimeters.
2. Multiply 12 by 25.4 to get 304.8 millimeters.

_____ b. If you needed to convert meters into feet, you should:

1. Simply find the conversion factor on an English-metric conversion chart, then multiply the meters by the conversion factor.
2. Use an English-metric conversion chart to find the conversion factor for feet, then multiply the feet by the conversion factor.

_____ c. In all cases, the conversion factor should be used to:

1. Multiply.
2. Divide.
3. Multiply or divide as the situation requires.

Objective 14

Solve problems about methods of sizing commonly used steel stock. Write the correct numbers in the blanks.

_____ a. Square bars, cold-rolled flat bars, and hot-rolled strips are usually sized by:

1. Thickness and length
2. Width and length
3. Width, thickness, and length

_____ b. When measuring a structural W beam, width has special significance because it refers to:

1. The width of the rising member
2. The width of the flange

_____ c. When measuring both structural W and structural S beams, T has a special significance because it refers to:

1. The thickness of the web
2. The thickness of the flange

_____ d. The flange width in bar and structural tees is indicated by the:

1. Letter W
2. Letter F

_____ e. The basic difference between measuring hot-rolled half ovals and hot and cold-rolled rounds is that:

1. Half ovals should have the width measured at their base and rounds should have their diameter measured because that is the width
2. One is measured by the diameter at its base, the other by the diameter at its middle

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 7
b. 4
c. 9
d. 12
e. 5
f. 1
g. 11
h. 10
i. 2
j. 6
k. 13
l. 3
m. 8

Objective 2

a. 4
b. 7
c. 9
d. 11
e. 1
f. 5
g. 12
h. 14
i. 2
j. 13
j. 8
k. 3
l. 6
m. 10

Objective 3

a. Quick reference
b. Greater accuracy
c. Decimals into fractions

Objective 4

b

Objective 5

a. Unit
b. Tenths
c. Hundredths
d. Thousandths
e. Ten thousandths
f. Hundred thousandths
g. Millionths

Objective 6

a. Decimal rule: Tenths, hundredths, thousandths
b. Metric rule: Meter, decimeter, centimeter, millimeter
c. Fractional rule: Eighths, sixteenths, thirty-seconds, sixty-fourths

Note: Any two graduations are acceptable for each rule.

Objective 7

a. 3
b. 2
c. 4
d. 1

Objective 8

a. 9
b. 7
c. 14
d. 1
e. 13
f. 10
g. 6
h. 8
i. 2
j. 4
k. 5
l. 3
m. 12
n. 11

Answers to Written Test

Objective 9

a. 4
b. 7
c. 1
d. 6
e. 3
f. 5
g. 2

Objective 10

a. 5
b. 1
c. 3
d. 6
e. 4
f. 2

Objective 11

a. 2
b. 1
c. 3

Objective 12

a. 900 sq. ft.
b. 452.16 sq. yd.
c. 18 sq. in.
d. 112 sq. mi.
e. 8,704 sq. mi.
f. 16 1/4 sq. rods

Objective 13

a. 2
b. 1
c. 1

Objective 14

a. 3
b. 2
c. 1
d. 2
e. 1

Teacher Supplement 1—English-Metric Conversions

Some of the welding certification tests administered by the American Welding Society require the applicant to convert metric measurements to English measurements. Objective 13 and Assignment Sheet 13 of this unit introduce the student to two basic conversion procedures, one for length and one for weight. The English-metric conversion charts included with this supplement are presented for reference. If students appear to require more instruction in the conversion procedure, items may be quickly prepared from the conversion charts.

	When You Know	You Can Convert To	When You Multiply By the Conversion Factor
LENGTH	Inches	Millimeters (mm)	25.4
	Millimeters	Inches	0.04
	Inches	Centimeters (cm)	2.54
	Centimeters	Inches	0.4
	Inches	Meters (m)	0.0254
	Meters	Inches	39.37
	Feet	Centimeters	30.5
	Centimeters	Feet	4.8
	Feet	Meters	0.305
	Meters	Feet	3.28
	Miles	Kilometers (km)	1.61
	Kilometer	Miles	0.62
AREA	Inches^2	Millimeters^2 (mm^2)	645.2
	Millimeters^2	Inches^2	0.0016
	Inches^2	Centimeters^2 (cm^2)	6.45
	Centimeters^2	Inches^2	0.16
	Foot^2	Meters^2 (m^2)	0.093
	Meters^2	Foot^2	10.76

Teacher Supplement 1

	When You Know	You Can Convert To	When You Multiply By the Conversion Factor
ACCELERATION	Inch/Sec^2	Meter/Sec^2	0.0254
	Meter/Sec^2	Inch/Sec^2	39.37
	Foot/Sec^2	Meter/Sec^2 (m/s^2)	0.3048
	Meter/Sec^2	Foot/Sec^2	3.280
TORQUE	Pound-Inch (Inch-Pound)	Newton-Meters (N-M)	0.113
	Newton-Meters	Pound-Inch	8.857
	Pound-Foot (Foot-Pound)	Newton-Meters	1.356
	Newton-Meters	Pound-Foot	0.737
PRESSURE	Pound/sq. in. (PSI)	Kilopascals (kPa)	6.895
	Kilopascals	Pound/sq. in.	0.145
	Inches of Mercury (Hg)	Kilopascals	3.377
	Kilopascals	Inches of Mercury (Hg)	0.296
FUEL PERFORMANCE	Miles/gal	Kilometers/liters (km/l)	0.425
	Kilometers/liters	Miles/gal	2.352
VELOCITY	Miles/hour	Kilometers/hr (km/h)	1.609
	Kilometers/hour	Miles/hour	0.621
TEMPERATURE	Degrees Fahrenheit	Degrees Celsius	5/9 (F° —32)
	Degrees Celsius	Deees Fahrenheit	9/5 (C°) +32 = F°
CAPACITY-VOLUME	Ounces	Milliliters (ml)	30.
	Milliliters	Ounces	0.034
	Pints	Liters (l)	0.47
	Liters	Pints	2.1
	Quarts	Liters	0.95
	Liters	Quarts	1.06
	Gallons	Liters	3.8
	Liters	Gallons	0.26
	Cubic Inches	Liters	0.0164
	Liters	Cubic Inches	61.03
	Cubic Inches	Cubic Centimeters (cc)	16.39
	Cubic Centimeters	Cubic Inches	0.061
WEIGHT (MASS)	Ounces	Grams	28.4
	Grams	Ounces	0.035
	Pounds	Kilograms	0.45
	Kilograms	Pounds	2.2
FORCE	Ounce	Newtons (N)	0.278
	Newtons	Ounces	35.98
	Pound	Newtons	4.448
	Newtons	Pound	0.225
	Newtons	Kilograms (kg)	0.102
	Kilograms	Newtons	9.807

Decimal Equivalent Chart

1/64	.015625	33/64	.515625
1/32	.03125	17/32	.53125
3/64	.046875	35/64	.546875
1/16	.0625	9/16	.5625
5/64	.078125	37/64	.578125
3/32	.09375	19/32	.59375
7/64	.109375	39/64	.609375
1/8	.125	5/8	.625
9/64	.140625	41/64	.640625
5/32	.15625	21/32	.65625
11/64	.171875	43/64	.671875
3/16	.1875	11/16	.6875
13/64	.203125	45/64	.703125
7/32	.21875	23/32	.71875
15/64	.234375	47/64	.734375
1/4	.25	3/4	.75
17/64	.265625	49/64	.765625
9/32	.28125	25/32	.78125
19/64	.296875	51/64	.796875
5/16	.3125	13/16	.8125
21/64	.328125	53/64	.828125
11/32	.34375	27/32	.84375
23/64	.359375	55/64	.859375
3/8	.375	7/8	.875
25/64	.390625	57/64	.890625
13/32	.40625	29/32	.90625
27/64	.421875	59/64	.921875
7/16	.4375	15/16	.9375
29/64	.453125	61/64	.953125
15/32	.46875	31/32	.96875
31/64	.484375	63/64	.984375
1/2	.5	1	1.

Inches-to-Decimal Conversion Chart

Fractions of Inches

1/16"	.0052
3/32"	.0078
1/8"	.0104
5/32"	.0130
3/16"	.0156
7/32"	.0182
1/4"	.0208
9/32"	.0234
5/16"	.0260
3/8"	.0313
7/16"	.0364
1/2"	.0417
9/16"	.0468
5/8"	.0521
11/16"	.0572
3/4"	.0625
13/16"	.0677
7/8"	.0726
15/16"	.0781

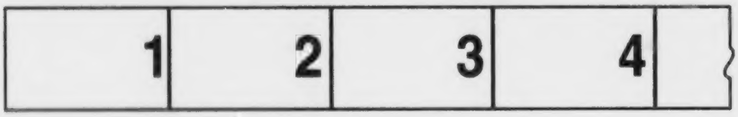
Inches

1"	.0833
2"	.1667
3"	.2500
4"	.3333
5"	.4167
6"	.5000
7"	.5833
8"	.6667
9"	.7500
10"	.8333
11"	.9167
12"	1.0000

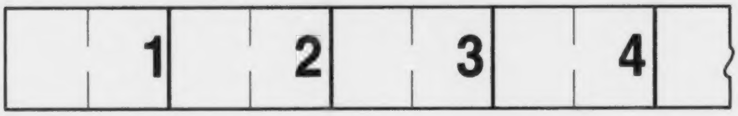
Note: Do not confuse inches-to-decimal with decimal equivalents.

Graduations on a Rule

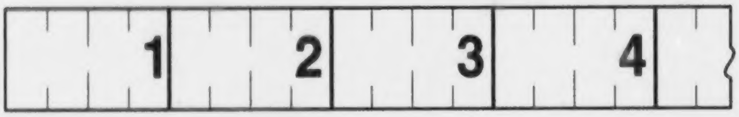
Inches



Halves

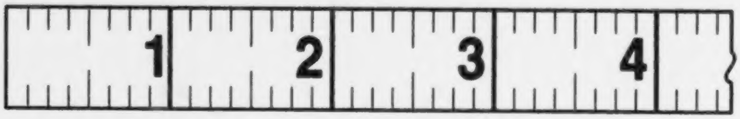


Quarters or Fourths

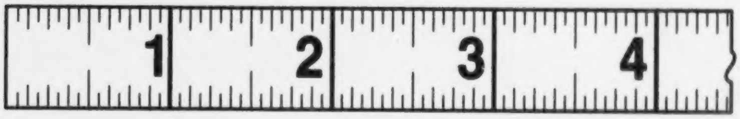


Graduations on a Rule (continued)

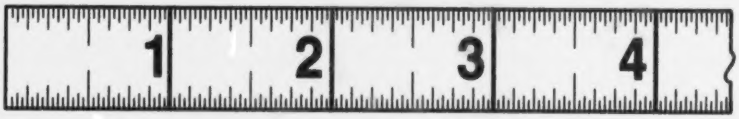
Eighths



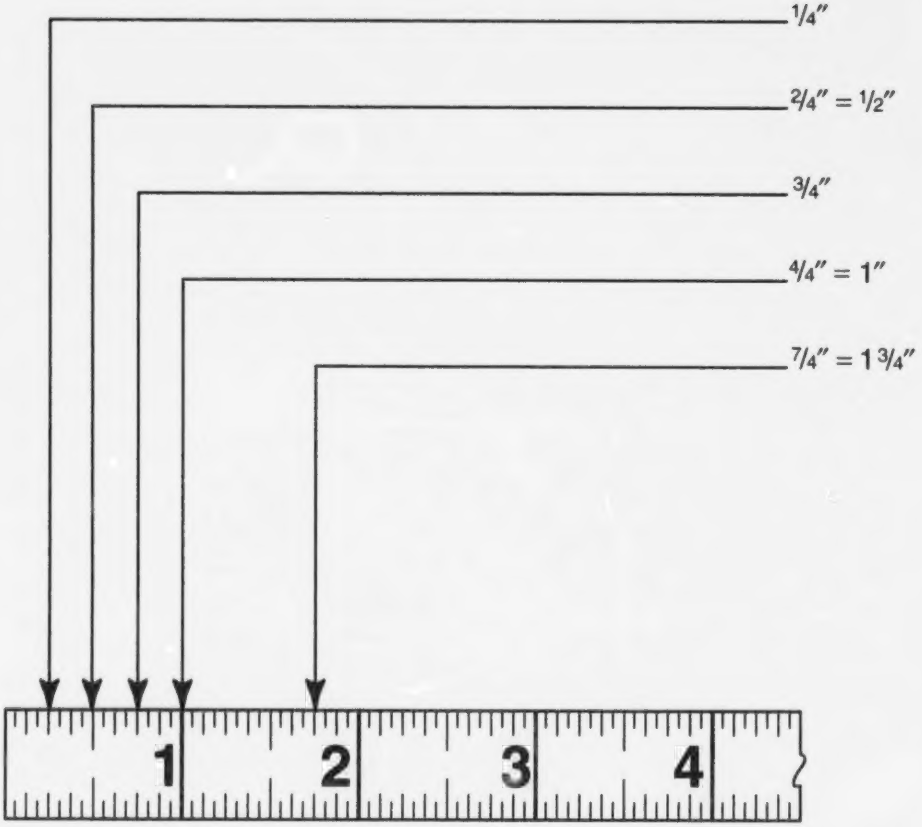
Sixteenths



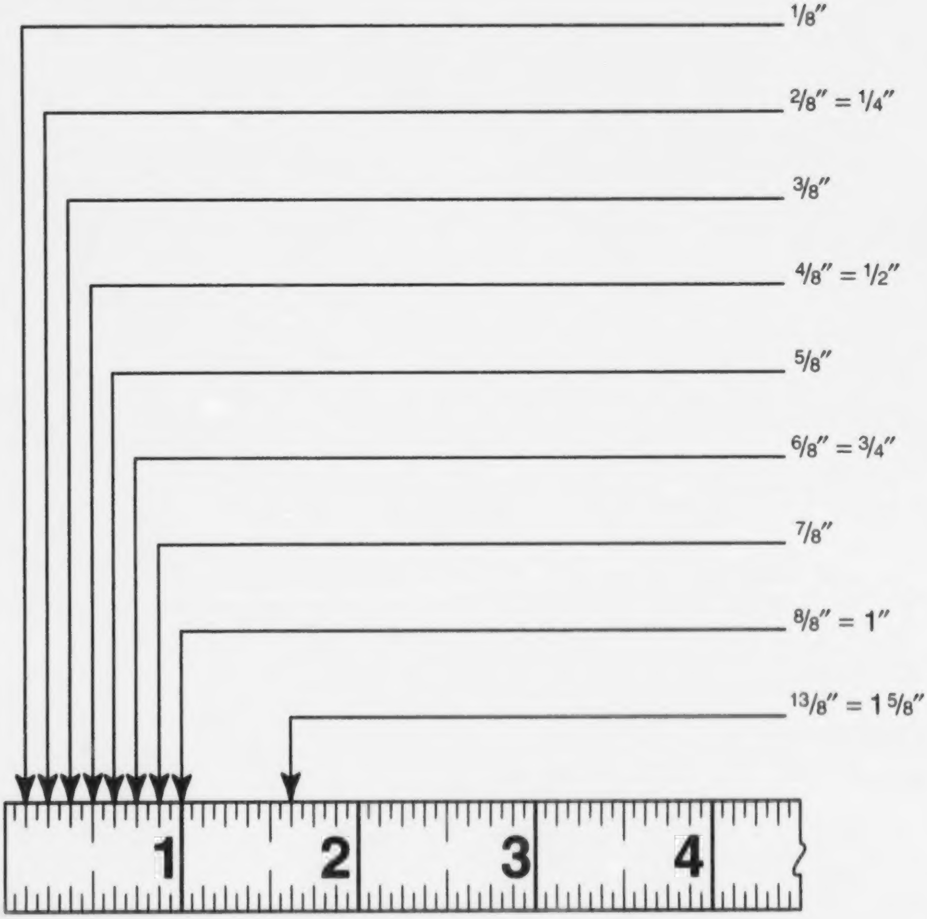
Thirty-Seconds



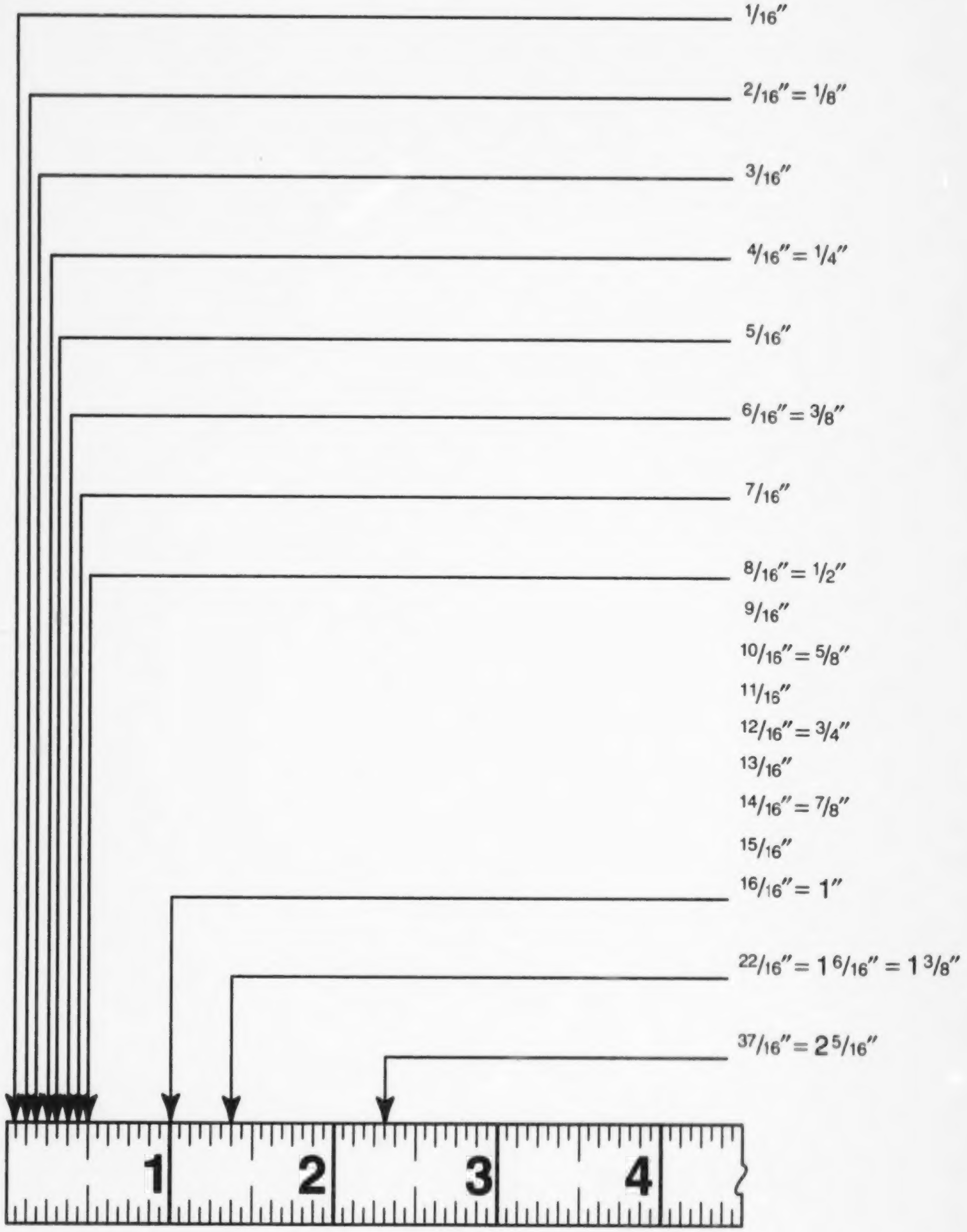
Reading Fourths on a Rule


1/4"
2/4" = 1/2"
3/4"
4/4" = 1"
7/4" = 1 3/4"
1
2
3
4

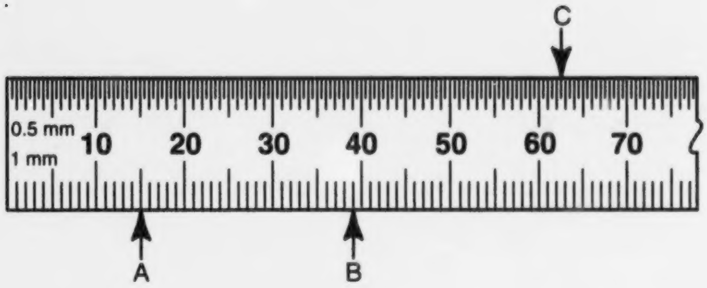
Reading Eighths on a Rule


1/8"
2/8" = 1/4"
3/8"
4/8" = 1/2"
5/8"
6/8" = 3/4"
7/8"
8/8" = 1"
13/8" = 1 5/8"
1
2
3
4

Reading Sixteenths on a Rule


1/16"
2/16" = 1/8"
3/16"
4/16" = 1/4"
5/16"
6/16" = 3/8"
7/16"
8/16" = 1/2"
9/16"
10/16" = 5/8"
11/16"
12/16" = 3/4"
13/16"
14/16" = 7/8"
15/16"
16/16" = 1"
22/16" = 1 6/16" = 1 3/8"
37/16" = 2 5/16"
1
2
3
4

Reading Measurements on a Metric Rule



Metric rule with 1-mm and 0.5-mm graduations

1. Read the measurement to reference point A.

   The measurement to reference point A is 10 mm plus 5 mm.

   A = 10 mm + 5 mm = 15 mm

2. Read the measurement to reference point B.

   The measurement to reference point B is 1 mm less than 40 mm.

   B = 40 mm – 1 mm = 39 mm

3. Read the measurement to reference point C.

   The measurement to reference point C is 60 mm plus two 1- mm graduations plus one 0.5-mm graduation.

   C = 60 mm + 2 mm + 0.5 mm = 62.5 mm

TM 8

Unit 7

Welding Print Reading

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Answers to Assignment Sheets 7–7

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Transparency Masters

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  1—Common Abbreviations and Their Meanings 7–29
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*Assignment Sheets

  1—Construct a Top View 107
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  6—Construct Missing Visible and Hidden Lines . . . 121
  7—Make a Three-View Sketch 123
  8—Construct Adjacent Parts in an Assembly Section . . . 125

*Assignment Sheets are located in the Student Workbook.

Instructional Plan

Suggested Activities

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make copies of any teacher supplements that will be provided for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

  TM 1—Formal Bill of Material (Objective 15)
  TM 2—Informal Bill of Material (Objective 16)

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.

Suggested Activities

- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.

Teaching Suggestions

- Invite the drafting instructor at your school to demonstrate to the class some of the basic drafting skills they can use to help make the assignment sheets both easier and accurate.
- Check around your school or with local architects for construction prints that call for welding activity. Share the print(s) with the class and point out how the lines and symbols they'll be learning in this unit are applied in the real world.
- Invite a local or area welding shop operator or an area fabricator who uses welders in industry or construction. Ask the operator to talk to the students about the need for print reading abilities and what those abilities can add to a person's job-getting skills and income level.
- Notify students that skills learned in this unit of instruction will be required to complete activities in the next unit, "Basic Welding Joints and Symbols." Students will be challenged to read a welding print complete with welding symbols. Both print reading capabilities and welding symbol interpretation are required when working with workplace welding prints. The two are presented together in the next unit, and students should be prepared to exercise print reading skills developed from study and work with this unit.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.
- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.
- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- Fortney, Clarence and Mike Gregory. *Welding Blueprint Reading and Layout*. Stillwater, OK: The Mid-America Vocational Curriculum Consortium, 1984.
- *The Procedure Handbook of Arc Welding*. Cleveland, OH: The Lincoln Electric Company, 1973.
- Schertz, Karen. *Basic Drafting*. Stillwater, OK: The Mid-America Vocational Curriculum Consortium, 1990.
- Volume 1, *Welding Technology Welding Handbook*, 8th ed. Miami, FL: American Welding Society, 1987.
- Volume 2, *Welding Technology Welding Processes*, 8th ed. Miami, FL: American Welding Society, 1989.

Suggested Supplemental Resources

Print Media

- Siy, Louis J., and A.E. Bennet. *Blueprint Reading for Welders, Sixth Edition*. Albany, NY: Delmar Publishers, Inc., 1999.

  Order online from Delmar Publishers at www.delmar.com, or call (800) 347-7707.
- *Joint Weld Terminology and Standard Welding Symbol Interpretation*. Miami, FL: American Welding Society, 1995.
- *Volume 2, Welding Technology Welding Handbook, Eighth Edition*. Miami, FL: American Welding Society, 1989.

  Order the two preceding books online from the American Welding Society at www.aws.org, or call (800) 334-9353.

Electronic Media

- Blueprint Reading for Welders and Fitters: 3-tape set (1 hr. 51 minutes)

  These videos can be purchased separately or as a set. Order online from the Hobart Institute of Welding Technology at www.welding.org, or call (800) 332-9448.
- Blueprint Reading Skills Explained: 4-tape set (65 minutes)

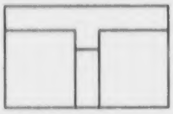
  Order these videos online from Bergwall at www.bergwall.com, or call (800) 645-3565.

Answers to Assignment Sheets

Assignment Sheet 1

Construct a Top View

1.



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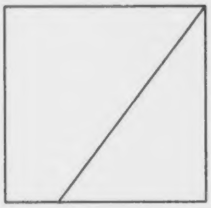

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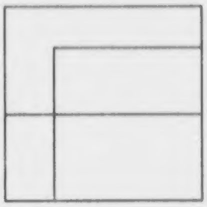

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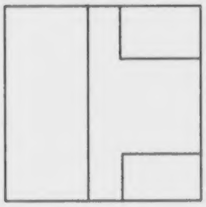
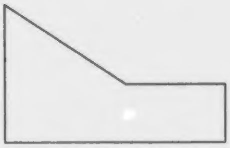


Assignment Sheet 2

Construct a Front View

1.



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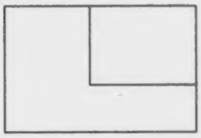

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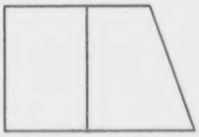
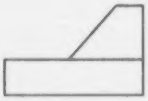


Answers to Assignment Sheets

Assignment Sheet 3

Construct a Right Side View

1.



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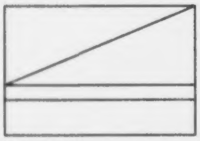

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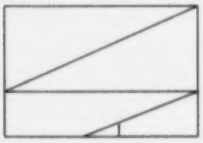

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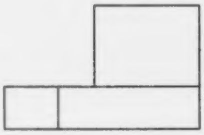
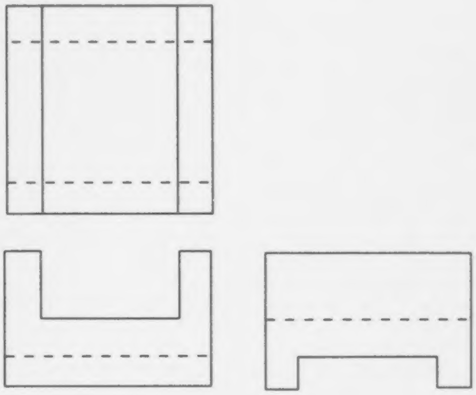


Assignment Sheet 4

Construct Missing Hidden Lines

1.



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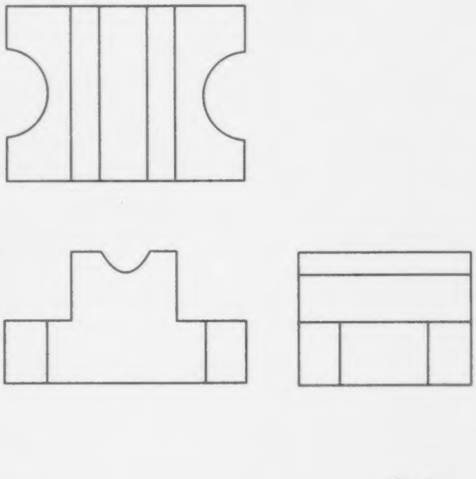

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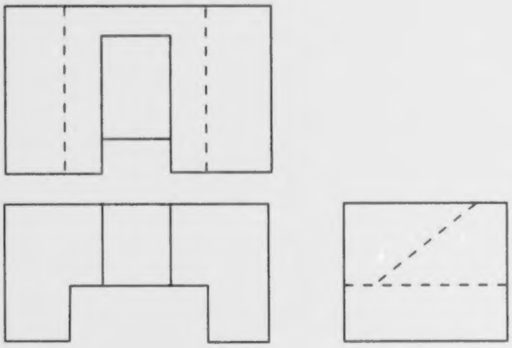

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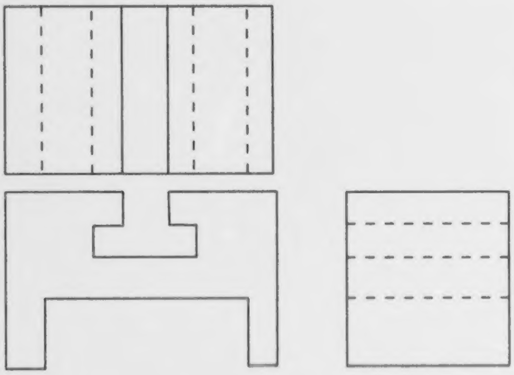


Assignment Sheet 5

Interpret Tolerance Dimensions in Decimals, Fractions, and Degrees

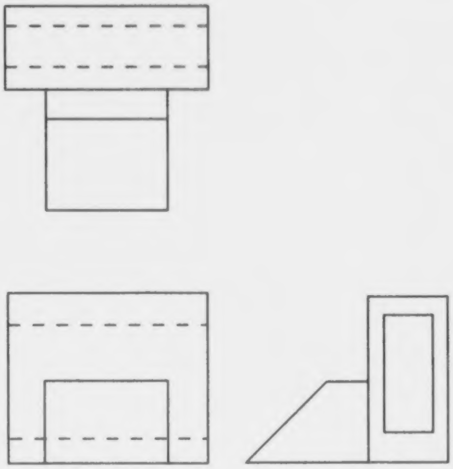
1.	Maximum limit	.375	6.	Maximum limit	4′6 41/64″
	Minimum limit	.372		Minimum limit	4′6 31/64″
	Total tolerance	.003		Total tolerance	5/32″
2.	Maximum limit	1.742	7.	Maximum limit	92°
	Minimum limit	1.738		Minimum limit	87°
	Total tolerance	.004		Total tolerance	5°
3.	Maximum limit	0.995	8.	Maximum limit	111°7′
	Minimum limit	0.990		Minimum limit	110°13′
	Total tolerance	.005		Total tolerance	54°
4.	Maximum limit	6 7/8″	9.	Maximum limit	125°3′
	Minimum limit	6 3/8″		Minimum limit	117°41′
	Total tolerance	1/2″		Total tolerance	7°22′
5.	Maximum limit	8 13/32″			
	Minimum limit	7 31/32″			
	Total tolerance	7/16″			

Answers to Assignment Sheets

Assignment Sheet 6

Construct Missing Visible and Hidden Lines

1.



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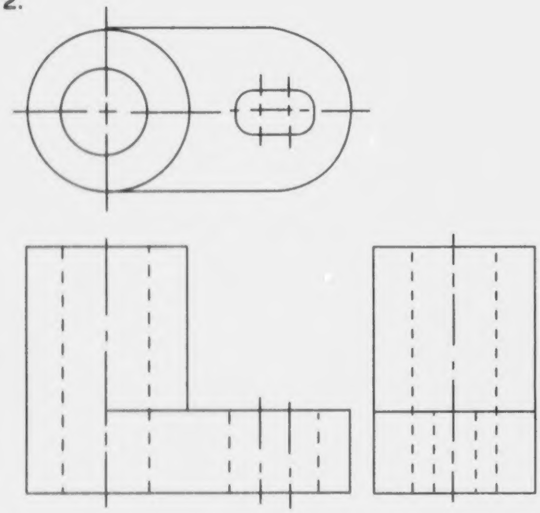

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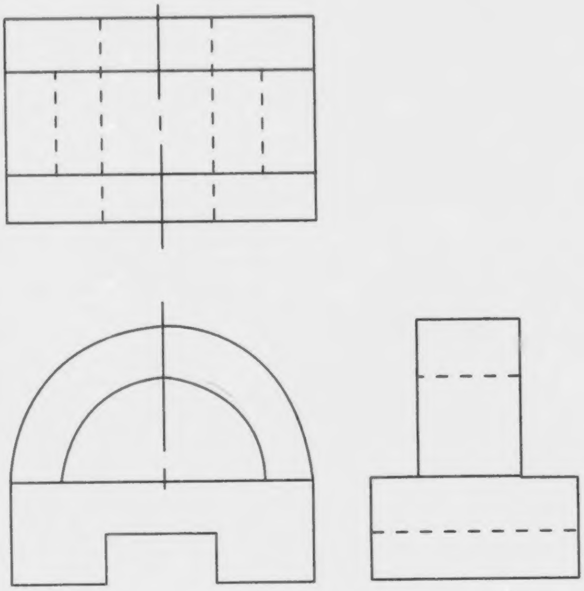

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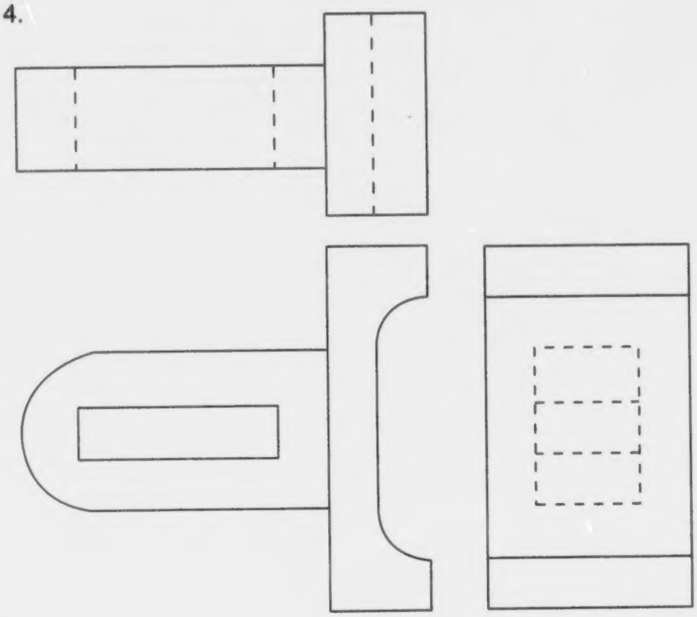
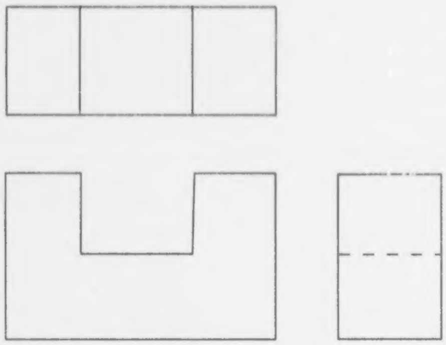


Answers to Assignment Sheets

5.



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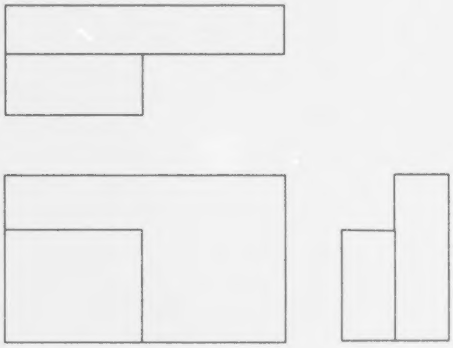

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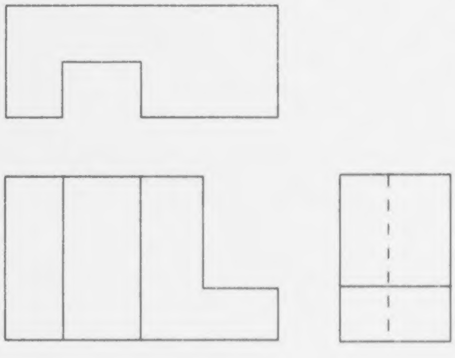

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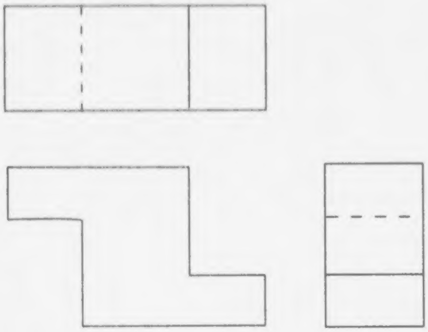

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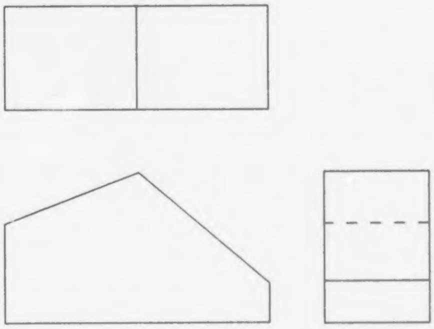

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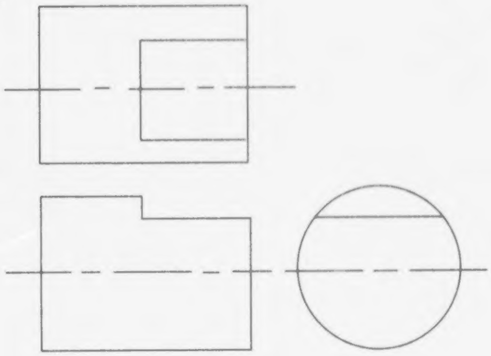
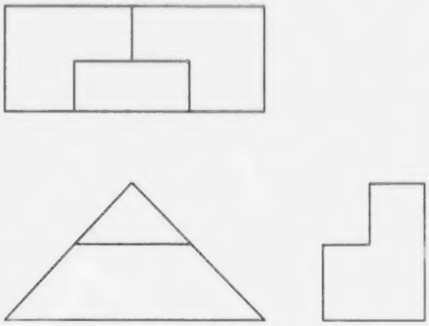


Answers to Assignment Sheets

11.



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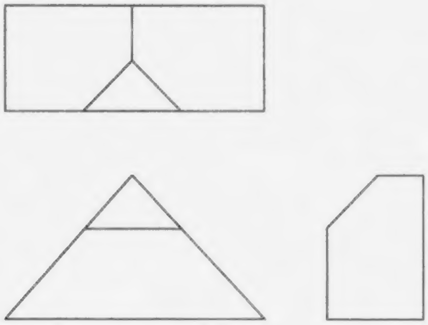

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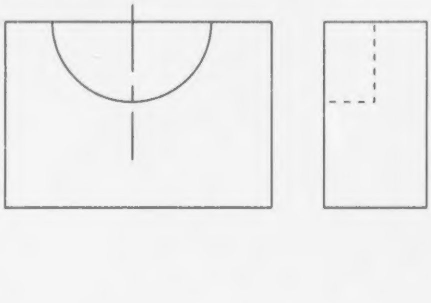

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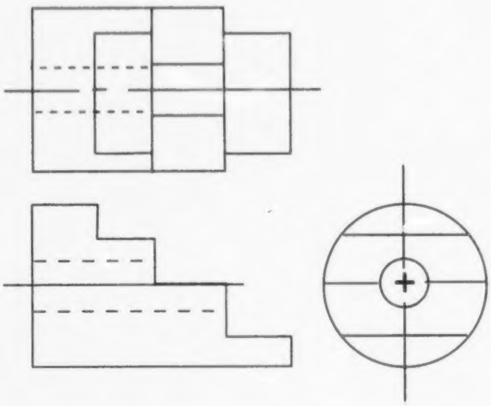

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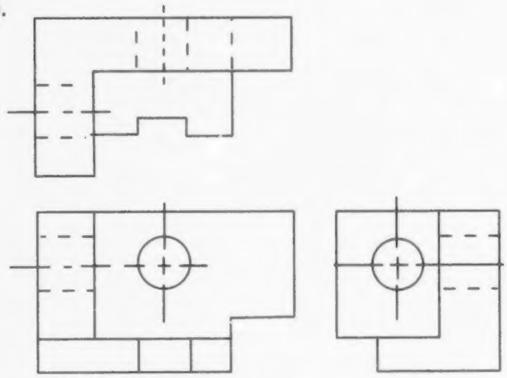

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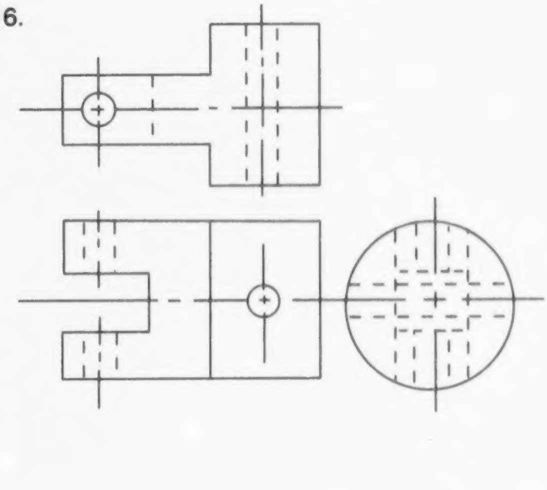
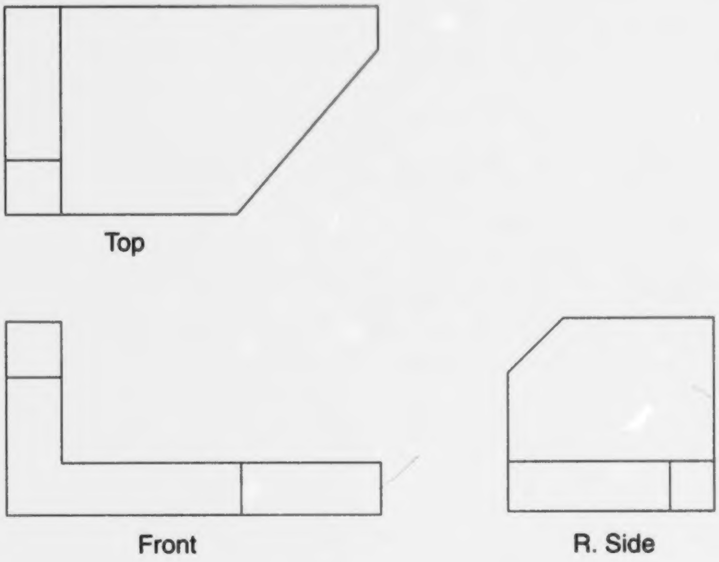


Answers to Assignment Sheets

Assignment Sheet 7

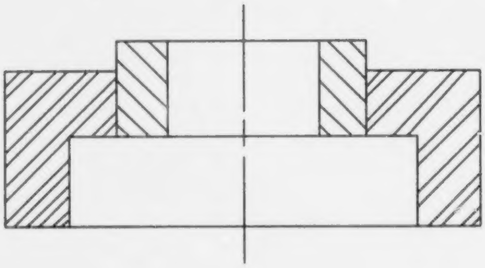
Make a Three-View Sketch


Top
Front
R. Side

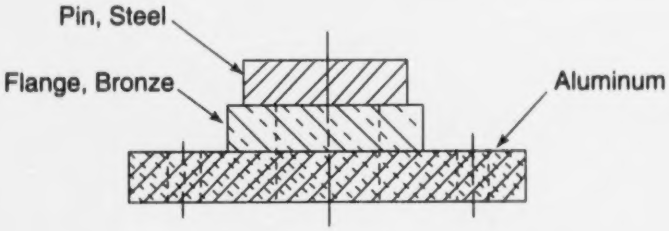
Assignment Sheet 8

Construct Adjacent Parts in an Assembly Section

A.



B.


Pin, Steel
Flange, Bronze
Aluminum

Written Test

Name ______________________________

Date ____________________ Score __________

Objective 1

Match terms related to welding print reading terms with their definitions.

1. Basic views
2. Basic lines
3. Welding print
4. Specifications
5. Tolerance
6. Working drawing
7. Notes
8. Dimensions
9. Symbol

_____ a. A copy of an original drawing that uses lines, symbols, and other pictorial elements to show how a part or assembly should be made

_____ b. An adaption of a print in total or in part to detail fabrication requirements of specific components in a production or job shop environment

_____ c. Information in capital letters or numbers concerning details of construction

_____ d. A listing of specific materials, welding process, electrode, rod, or other specific requirements

_____ e. A pictorial view of a standard shape, line, material, or other items of information

_____ f. A set of lines, arrows, and dashes used to represent size, shape, location, or composition of an object

_____ g. Numbers used to define size and location

_____ h. A pictorial or orthographic projection of an object that displays its complex size and shape from all necessary sides

_____ i. The total amount by which a specific dimension is permitted to vary in maximum and minimum limits usually expressed as a plus or minus value

Written Test

Objective 2

Match basic lines with their uses. Write the correct numbers in the blanks.

1.	Center lines	7.	Viewing plane lines
2.	Cutting plane lines	8.	Object or visible lines
3.	Phantom lines	9.	Leader lines
4.	Hidden lines	10.	Section lines
5.	Long break lines	11.	Extension lines
6.	Dimension lines	12.	Short break lines

_____ a. Thick, unbroken lines used to indicate the visible shape of an object

_____ b. Medium thickness lines of short dashes used to indicate interior details of an object that are not visible

_____ c. Thin lines that have dimensions inserted at the center and are terminated by arrowheads at each end

_____ d. Thin lines used for placing limits on dimension; these do not touch, but extend from the height, width, and length of an object

_____ e. Thin lines with alternating long and short dashes used to indicate the center of objects, holes, arcs, and symmetrical shapes; also used as extension lines for dimensions

_____ f. Thick wavy lines used to indicate that an object has been slightly shortened to conserve space but still provide clarity

_____ g. Thin lines with sharp spur-shaped variations above and below the line to indicate that an object has been greatly shortened to conserve space

_____ h. Fine, straight lines with an arrow or a dot at one end which points directly to a surface area or specific point for the purpose of dimensioning or adding a note

_____ i. Thick, broken lines of two short and one long sections used to indicate an imaginary cut through an object, with arrowheads terminating at right angles to the line to indicate direction in which the cut area should be viewed

_____ j. Lines that look like cutting plane lines, but instead of cutting through a shape, they are used to indicate that the surface should be viewed in the direction of the arrow heads

_____ k. Series of fine lines used to indicate the area of an imaginary cut made by a cutting plane line, and are normally identified by letters that reference the cutting plane letters

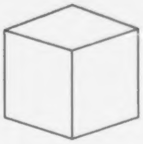
_____ l. Thin lines with alternating long and short dashes to indicate other positions to which a part or an object can be moved

Objective 3

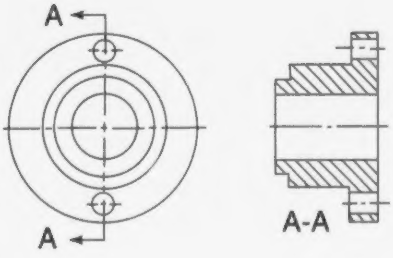
Identify basic views. Place the number denoting the type of view beside the appropriate graphic.

1. Detail view
2. Orthographic projection, top view
3. Section view
4. Pictorial view
5. Orthographic projection, front view
6. Partial view
7. Orthographic projection, side view
8. Auxiliary view

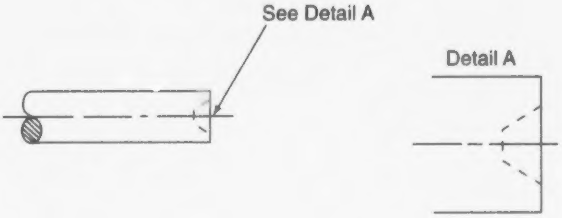
____ a.



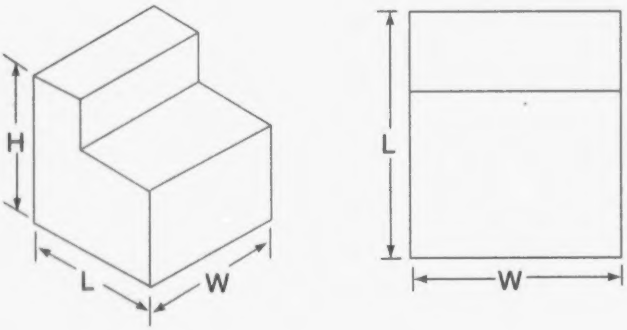
____ b.



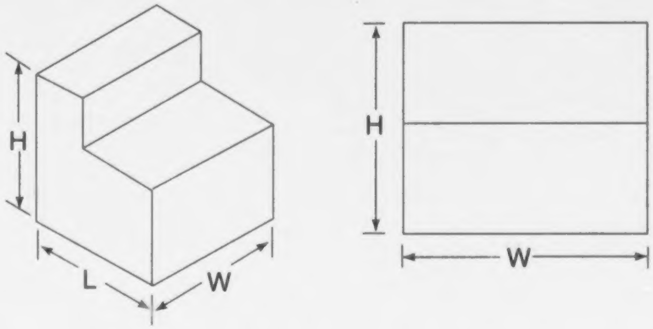
____ c.



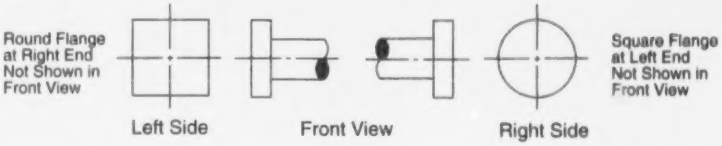
____ d.



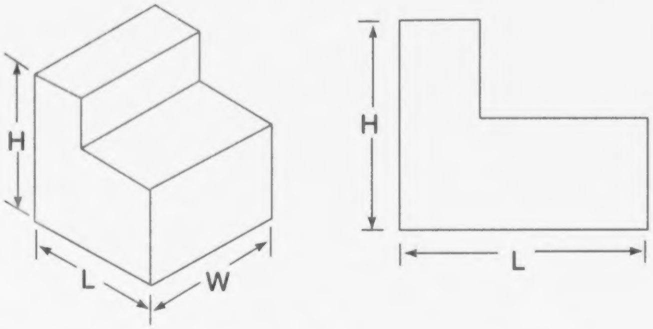
Written Test



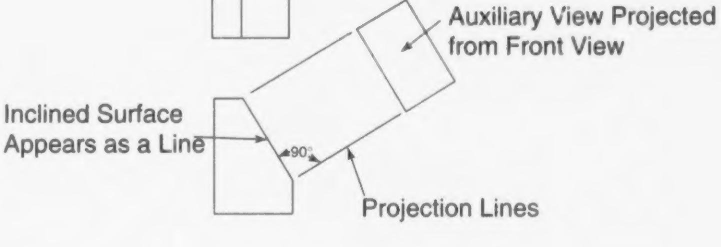
_____ e.


Round Flange at Right End Not Shown in Front View
Left Side
Front View
Right Side
Square Flange at Left End Not Shown in Front View

_____ f.



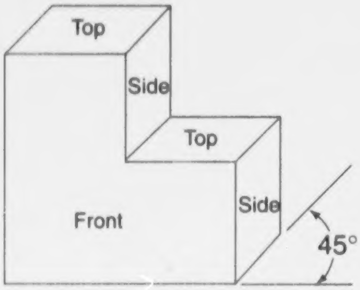
_____ g.


Auxiliary View Projected from Front View
Inclined Surface Appears as a Line
90°
Projection Lines

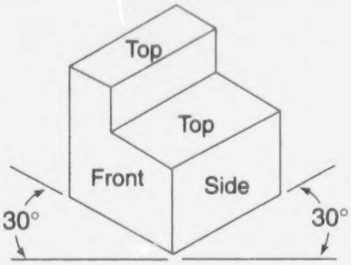
_____ h.

Objective 4

Differentiate between isometric and oblique drawings. Select the isometric drawing from the following graphics by placing an "X" in the blank next to it.



_____ a.



_____ b.

Objective 5

Solve problems related to dimensioning. Select the best answer for each of the following conditions.

_____ a. Whole numbers and fractions frequently used in welding dimensioning are used when:

1. Precision is required.
2. The print is large enough to facilitate the numbers.
3. Precise size is extremely remote.

_____ b. Decimals are used in machine shop dimensioning when:

1. A small print demands smaller numbers.
2. Close tolerances are necessary.
3. Decimals are used in other parts of the print.

_____ c. Angular dimensioning helps find the included angle which is expressed:

1. As a percentage of a horizontal plane.
2. As degrees or portions of degrees.
3. A groove or fillet construction.

Written Test

Objective 6

Solve problems related to tolerancing. Select the best answer for each of the following problems.

_____ a. You are working with a print that uses decimals for tolerancing, so what items do you expect to see?

1. Maximum and minimum limits expressed as ± 1/8".
2. Maximum and minimum limits expressed as ± 2°.
3. Maximum and minimum limits expressed as ± .010.

_____ b. A co-worker reading a print says that since the maximum tolerance stated is .010 and the minimum tolerance stated is also .010, then the total tolerance is obviously .010. Considering the stated tolerances, your co-worker is:

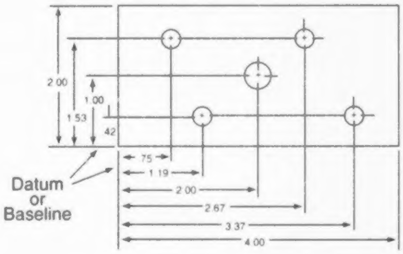
1. Right, because both tolerances are the same.
2. Wrong, because the two tolerances should be added together to produce total tolerance.
3. Wrong, because if maximum and minimum limits are given, total tolerance wouldn't be used.

_____ c. A co-worker tells you that working with tolerances stated in degrees is easy because it's stated in hours and minutes, just like telling time. Your co-worker is:

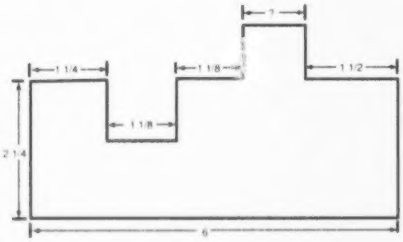
1. Wrong, because degrees and minutes used in tolerancing refer to distance, not to time.
2. Right, because all complete circles have 360°.
3. Wrong, because degrees and minutes used in tolerancing are the same as used for telling time, but they are used in a special way.

Objective 7

Differentiate between methods of dimensioning. Place an "X" beside the following illustration that reflects conventional dimensioning.



_____ a.



_____ b.

Objective 8

Select true statements about bevels and chamfers by placing an "X" in the blank next to each true statement.

_____ a. A bevel is a sloping surface which always extends the full length of an edge.

_____ b. Chamfer is another term for bevel, but chamfer is normally used in machine shop practice while bevel is used in welding applications.

Objective 9

Complete statements about reduction and enlargement scales. Circle the material that best completes each statement.

a. An enlargement scale presents an object larger than its actual size, and is usually expressed as **(twice, triple, quadruple, etc.) (2x, 3x, 4x, etc.)**.

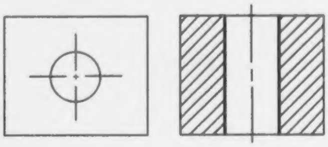
b. A reduction scale presents an object smaller than its actual size, and is usually expressed **(in decimals) (in fractions and inches)**.

Objective 10

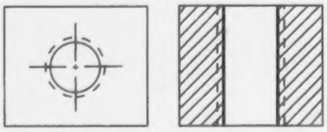
Identify types of holes. Place the number denoting the type of hole next to the appropriate graphic.

1. Counterbore
2. Drilled
3. Countersunk
4. Threaded

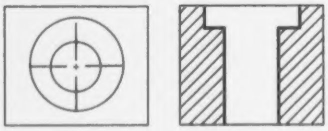
_____ a.



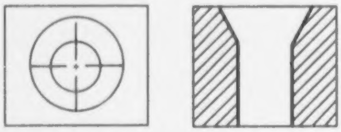
_____ b.



_____ c.



_____ d.

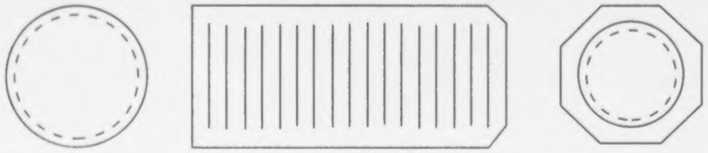


Written Test

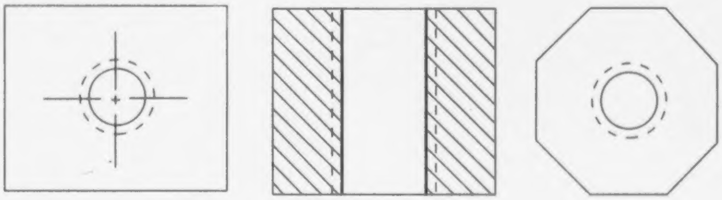
Objective 11

Differentiate between types of threads. Place an "I" beside the graphic of an internal thread and an "E" beside the graphic of an external thread.

_____ a.



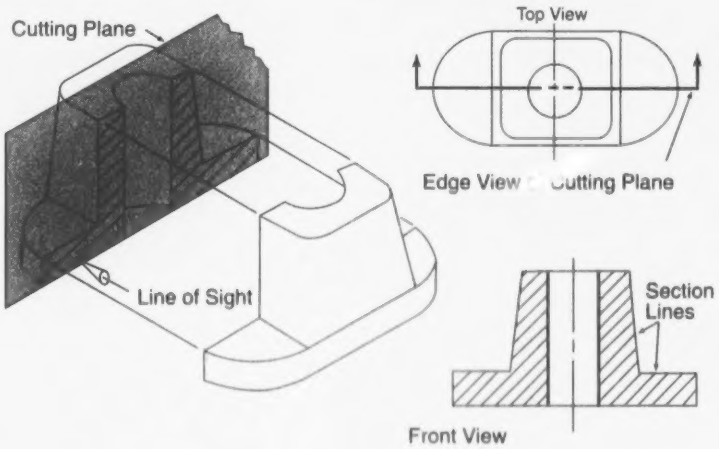
_____ b.



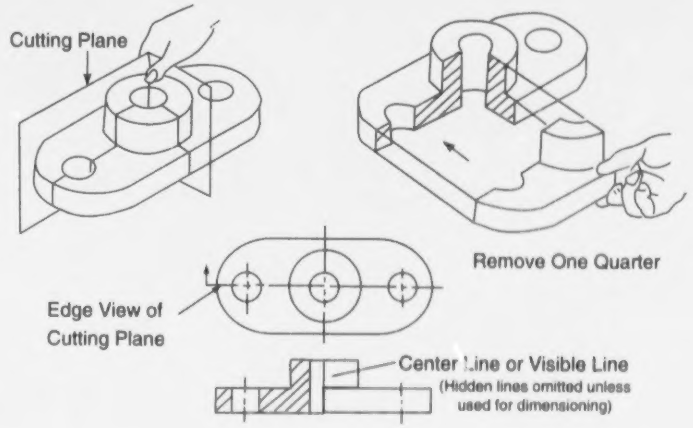
Objective 12

Identify types of section views. Place the number denoting the type of section view beside the appropriate graphic.

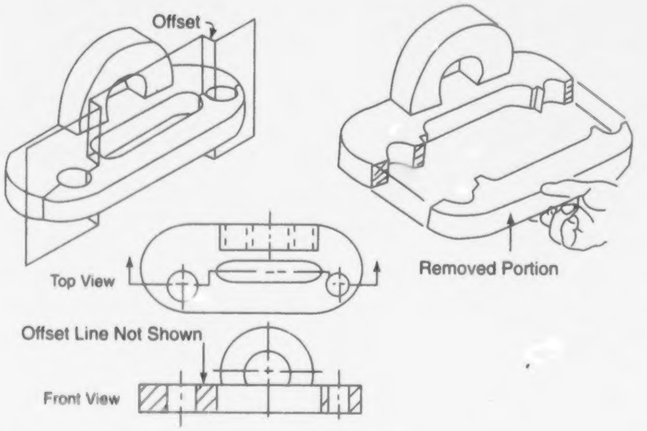
1. Revolved section
2. Half section
3. Full section
4. Offset section


Cutting Plane
Line of Sight
Top View
Edge View of Cutting Plane
Section Lines
Front View

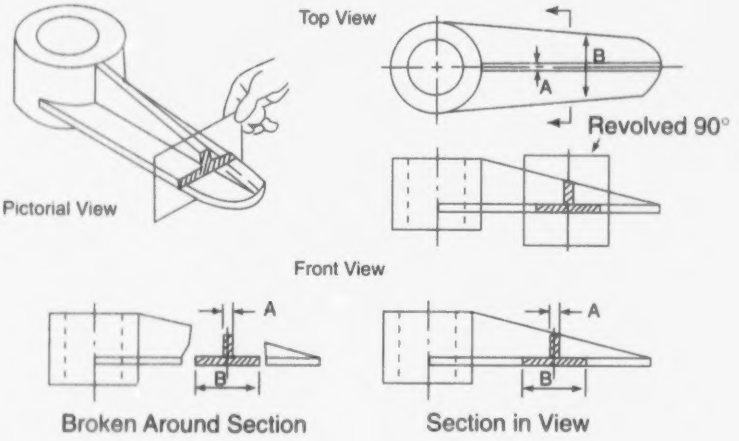
_____ a.


Cutting Plane
Remove One Quarter
Edge View of
Cutting Plane
Center Line or Visible Line
(Hidden lines omitted unless
used for dimensioning)

_____ b.


Offset
Top View
Removed Portion
Offset Line Not Shown
Front View

_____ c.


Top View
B
A
Revolved 90°
Pictorial View
Front View
A
B
A
B
Broken Around Section
Section in View

_____ d.

Written Test

Objective 13

Complete statements about other symbols. Circle the material that best completes each statement.

a. Material symbols use cross hatching lines to indicate **(planes on a surface) (composition of materials)**.

b. Stock components are depicted with **(pictorials) (lines)** that show their structural shapes.

c. Machine symbols indicate to what degree of smoothness a surface should be **(prepared) (finished)**.

d. **(An expanded metal symbol) (A knurling symbol)** is used to indicate that a gripping surface should be provided on a normally smooth surface.

e. An **(x) (s)** through a part indicates that an object is square when viewed from a side view.

Objective 14

Complete statements about structural shapes. Circle the material that best completes each statement.

a. Many structural shapes are common to all varieties of **(structural fabrication) (welding materials)**.

b. The symbols for structural shapes are **(isometric drawings) (miniature pictorials)** of the shapes themselves.

c. The fillet shape is an **(inside) (outside)** corner of a 90° angle whether machined smoothly or welded.

d. The round shape is an **(inside) (outside)** 90° corner.

e. A runout is a **(smooth continuation) (slight elevation)** of a change in direction to avoid a weakened area that could result from an abrupt change.

Objective 15

Select true statements about requirement for a formal bill of materials. Place an "X" beside each true statement.

_____ a. Should list the name of the firm that made the blueprint or drawing, the name of the form for whom the drawing was made, and list the drafter's initials, date of drawing, and initials of the drafting supervisor who checked the print

_____ b. Should list the part name last and items that define the part should precede the name

_____ c. Should detail parts individually so they will be easy to purchase

_____ d. Should specify quantities required, sizes required, and information relating specific grades, brand names, or standards to which the part must comply

_____ e. Should clarify notes with important information taken directly from the blueprint for drawing, and related references to job number, location, and other materials necessary to properly relate the material list to the specific application that the print calls for

Objective 16

Complete statements about the requirements for an informal bill of material. Circle the information that best completes each statement.

a. It should arrange the materials **(in numerical order) (alphabetically)**.

b. It should identify materials by a mark number **(in numerical sequence) (alphabetically)**.

c. It should specify the **(number) (quality)** required for each part.

d. It should clearly define size or dimension **(of all parts) (of parts that require such information)**.

e. It should note any other information that helps to clarify quality of material or elements in the original print or drawing that should be a reference for **(better understanding) (special order)** of what the part or material is used for.

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 3
b. 6
c. 7
d. 4
e. 9
f. 2
g. 8
h. 1
i. 5

Objective 2

a. 8
b. 4
c. 6
d. 11
e. 1
f. 12
g. 5
h. 9
i. 2
j. 7
k. 10
l. 3

Objective 3

a. 4
b. 3
c. 1
d. 2
e. 7
f. 6
g. 5
h. 8

Objective 4

b

Objective 5

a. 3
b. 2
c. 2

Objective 6

a. 3
b. 2
c. 1

Objective 7

b

Objective 8

b

Objective 9

a. 2x, 3x, 4x, etc.
b. In fractions and inches

Objective 10

a. 2
b. 4
c. 1
d. 3

Objective 11

a. E
b. I

Objective 12

a. 3
b. 2
c. 4
d. 1

Answers to Written Test

Objective 13

a. Composition of materials
b. Lines
c. Finished
d. A knurling symbol
e. x

Objective 14

a. Structural fabrication
b. Miniature pictorials
c. Inside
d. Outside
e. Smooth continuation

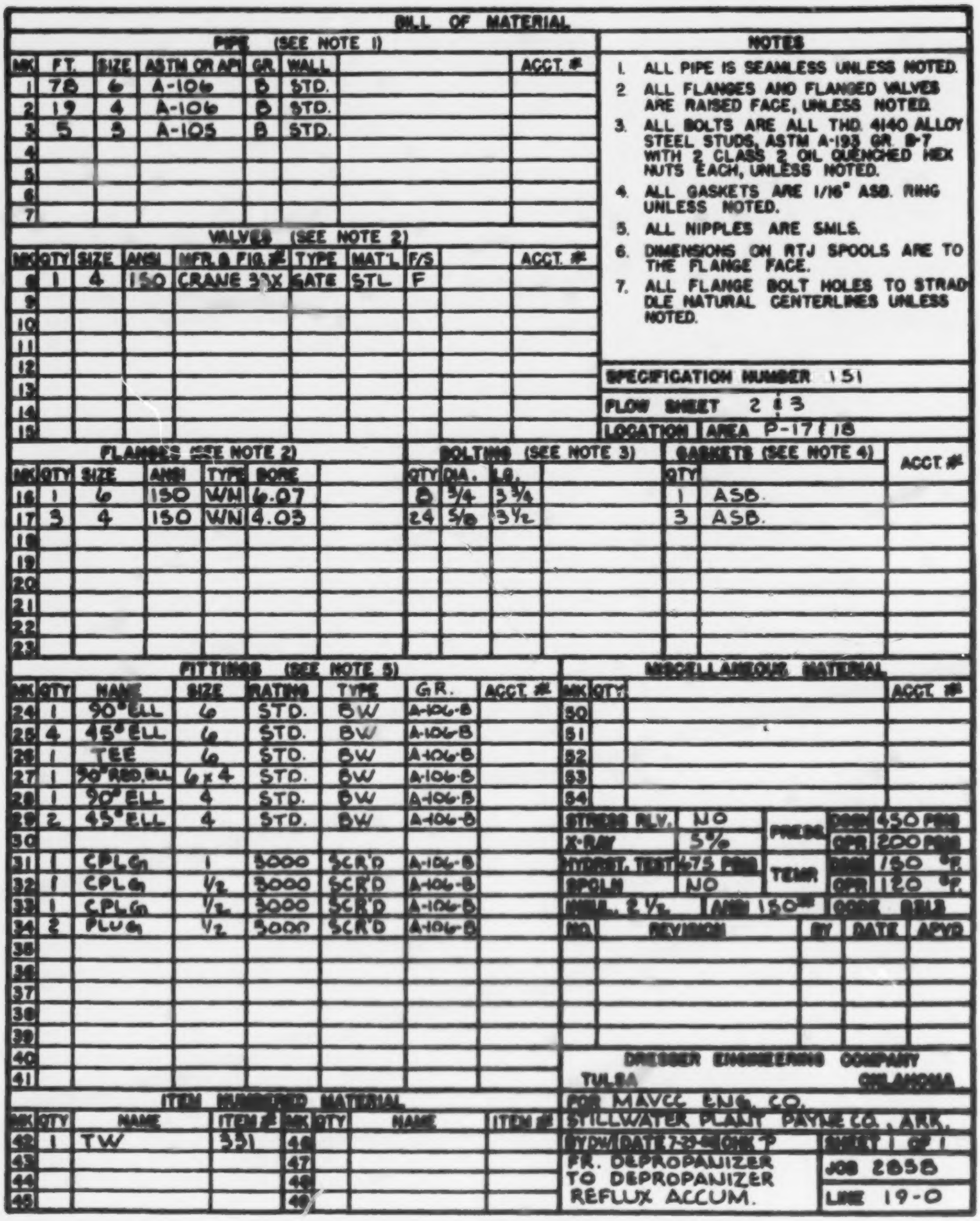
Objective 15

a, b, d, e

Objective 16

a. In numerical order
b. In numerical sequence
c. Number
d. Of parts that require such information
e. Better understanding

Formal Bill of Material



BILL OF MATERIAL

PIPE (SEE NOTE 1)

MK	FT.	SIZE	ASTM OR API	GR.	WALL.		ACCT. #
1	78	6	A-106	B	STD.		
2	19	4	A-106	B	STD.		
3	5	3	A-105	B	STD.		
4							
5							
6							
7							

VALVES (SEE NOTE 2)

MK	QTY	SIZE	ANSI	MFR. & FIG. #	TYPE	MAT'L	F/S		ACCT. #
8	1	4	150	CRANE 33X	GATE	STL	F		
9									
10									
11									
12									
13									
14									
15									

NOTES

1. ALL PIPE IS SEAMLESS UNLESS NOTED.
2. ALL FLANGES AND FLANGED VALVES ARE RAISED FACE, UNLESS NOTED.
3. ALL BOLTS ARE ALL THD. 4140 ALLOY STEEL STUDS, ASTM A-193 GR. B-7 WITH 2 CLASS 2 OIL QUENCHED HEX NUTS EACH, UNLESS NOTED.
4. ALL GASKETS ARE 1/16" ASB. RING UNLESS NOTED.
5. ALL NIPPLES ARE SMLS.
6. DIMENSIONS ON RTJ SPOOLS ARE TO THE FLANGE FACE.
7. ALL FLANGE BOLT HOLES TO STRADDLE NATURAL CENTERLINES UNLESS NOTED.

SPECIFICATION NUMBER 151

FLOW SHEET 2 & 3

LOCATION AREA P-17 & 18

FLANGES (SEE NOTE 2)							BOLTING (SEE NOTE 3)				GASKETS (SEE NOTE 4)		ACCT. #
MK	QTY	SIZE	ANSI	TYPE	BORE		QTY	DIA.	LG.		QTY		
16	1	6	150	WN	6.07		8	3/4	3 3/4		1	ASB.	
17	3	4	150	WN	4.03		24	5/8	3 1/2		3	ASB.	
18													
19													
20													
21													
22													
23													

FITTINGS (SEE NOTE 5)

MK	QTY	NAME	SIZE	RATING	TYPE	GR.	ACCT. #
24	1	90° ELL	6	STD.	BW	A-106-B	
25	4	45° ELL	6	STD.	BW	A-106-B	
26	1	TEE	6	STD.	BW	A-106-B	
27	1	90° RED. ELL	6 x 4	STD.	BW	A-106-B	
28	1	90° ELL	4	STD.	BW	A-106-B	
29	2	45° ELL	4	STD.	BW	A-106-B	
30							
31	1	CPLG	1	3000	SCR'D	A-106-B	
32	1	CPLG	1/2	3000	SCR'D	A-106-B	
33	1	CPLG	1/2	3000	SCR'D	A-106-B	
34	2	PLUG	1/2	3000	SCR'D	A-106-B	
35							
36							
37							
38							
39							
40							
41							

MISCELLANEOUS MATERIAL

MK	QTY		ACCT. #
50			
51			
52			
53			
54			

STRESS RLV.	NO	PRESS.	DSGN	450 PSIG
X-RAY	5%		OPR	200 PSIG
HYDROST. TEST	675 PSIG	TEMP.	DSGN	150 °F
SPOLN	NO		OPR	120 °F
INSUL. 2½	ANSI 150#	CODE B31.3		

NO.	REVISION	BY	DATE	APVD

DRESSER ENGINEERING COMPANY
TULSA OKLAHOMA

FOR MAVCC ENG. CO.

STILLWATER PLANT PAYNE CO., ARK.

BY DW DATE 7-2?-? CHK ? SHEET 1 OF 1

FR. DEPROPANIZER
TO DEPROPANIZER
REFLUX ACCUM.

JOB 2858

LINE 19-0

ITEM NUMBERED MATERIAL

MK	QTY	NAME	ITEM #	MK	QTY	NAME	ITEM #
42	1	TW	331	46			
43				47			
44				48			
45				49			

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Informal Bill of Material

NO. REQ'D	MATERIAL		MK.
8	3/8" PL 10" x 8 1/2"	S-A-36	1
2	3/8" PL 10" X 6 1/2"	S-A-36	2
2	3/8" PL 10" X 6 1/4"	S-A-36	3
2	3/8" PL 10" X 6 3/8"	S-A-36	4
2	3/8" PL 10" x 8 3/8"	S-A-36	5
1	3/8" PL 10" X 6 3/8"	SA-36	6
5	4 X 4 x 5/16" ∠	SA-36	7
5	DO	DO	8
2	4X4 x 5/16" ∠	DO	9
2	DO	DO	10
2	4 X 4 X 5/16" ∠	DO	11
2	DO	DO	12
4	5X 5X 3/8 ∠ X 2'-5 1/2	DO	13
1	3/8" PL-10" X 6 1/2	DO	14
2	3/8" PL-10" X 6 3/8"	DO	15
6	3/8" PL 19" X 6 1/2"	DO	16
6	3/8" PL 7" X 27"	-	17
20	3/8 PL 7" X 20"	-	18
2	DAVIT PL (SEE C-18002-5)		DP
1	DAVIT WT (See C- 18002-5)		DW

BEST COPY AVAILABLE

Unit 8 Basic Welding Joints and Symbols

Unit Contents

Teacher Page

Teacher Components

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Written Test 8–11

Answers to Written Test 8–21

Transparency Masters

1—Parts of a Welding Symbol 8–25
2—Typical Welded Joints and Positions 8–27
3—Welding Angle to Angle 8–29
4—Welding Angle to Channel 8–31
5—Welding Channel to Channel 8–33
6—Welding Channel to S or W Beams 8–35
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8—Welding Angle to S or W Beams 8–39

Student Page

Student Components

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Information Sheet 8–7

Student Supplement

1—Weld Symbols, Names, and Definitions 8–25

*Assignment Sheets

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2—Interpret Basic Welding Symbols 129
3—Interpret Working Welding Symbols 133
4—Draw Welding Symbols for Given Specifications 141
5—Interpret a Welding Print and Welding Procedure Specifications 145

*Assignment Sheets are located in the Student Workbook.

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

  TM 1—Parts of a Welding Symbol (Objectives 5–12)
  TM 2—Typical Welded Joints and Positions (Objective 9)
  TM 3—Welding Angle to Angle (Objective 14)
  TM 4—Welding Angle to Channel (Objective 14)
  TM 5—Welding Channel to Channel (Objective 14)
  TM 6—Welding Channel to S or W Beams (Objective 14)
  TM 7—Welding S Beams to W or W to S Beams (Objective 14)
  TM 8—Welding Angle to S or W Beams (Objective 14)

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Suggested Activities

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.

Teaching Suggestions

- Place special emphasis on Objectives 1, 2, and 3 as you present this unit. The referenced objectives cover the basics of weld and welding symbols along with the terminology required to understand symbol applications.
- Stress the difference between a weld symbol and a welding symbol as they are illustrated in Objective 5. Make sure students understand and appreciate the difference between the two.
- As you teach Objective 6 and the objectives that follow, have students begin sketching welding symbols and the supplementary symbols that go with them. This will prepare them to better handle the assignment sheets that conclude the unit.
- When you teach dimensioning symbols, have students measure and write dimensioning information for workpieces they have completed themselves. Pay particular attention to the dimensioning of fillet welds.
- The weld symbols, names, and definitions included in the extensive list in Student Supplement 1 are designed not only for reference, they can be used for chalkboard tests. Put a symbol a day on the chalkboard and have students reference Supplement 1 until they can identify symbols, or relate symbols to definitions without using the supplement.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.

Suggested Activities

- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.
- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- Connor, Leonard P., ed. *Welding Handbook, Eighth Edition, Vol. 1, Welding Technology*. Miami, FL: American Welding Society, 1987.
- O'Brien, R. L., ed. *Welding Handbook, Eighth Edition, Vol. 1, Welding Processes*. Miami, FL: American Welding Society, 1991.
- *Standard for Welding Procedure and Performance Qualification*, AWS B2.1-84. Miami, FL: American Welding Society, 1987.
- *Standard Symbols for Welding, Brazing, and Nondestructive Testing*, ANSI/AWS A2.486. Miami, FL: American Welding Society, 1986.
- *Standard Welding Terms and Definitions*, ANSI/AWS A3.0-89. Miami, FL: American Welding Society, 1989.

Suggested Supplemental Resources

Print Media

- Siy, Louis J., and A.E. Bennet. *Blueprint Reading for Welders, Sixth Edition*. Albany, NY: Delmar Publishers, Inc., 1999.

  Order online from Delmar Publishers at www.delmar.com, or call (800) 347-7707.
- *Joint Weld Terminology and Standard Welding Symbol Interpretation*. Miami, FL: American Welding Society, 1995.
- *Volume 2, Welding Technology Welding Handbook, Eighth Edition*. Miami, FL: American Welding Society, 1989.

  Order the two preceding books online from the American Welding Society at www.aws.org, or call (800) 334-9353.

Suggested Activities

Electronic Media

Videotapes

- Blueprint Reading for Welders and Fitters: 3-tape set (1 hr. 51 minutes)

  These videos can be purchased separately or as a set. Order online from the Hobart Institute of Welding Technology at www.welding.org, or call (800) 332-9448.

- Blueprint Reading Skills Explained: 4-tape set (65 minutes)

  Order these videos online from Bergwall at www.bergwall.com, or call (800) 645-3565.

Answers to Assignment Sheets

Assignment Sheet 1

Identify Basic Weld Symbols

1. Melt through
2. U-groove
3. Surfacing
4. Spot or projection
5. Staggered intermittent fillet
6. V-groove
7. Square groove
8. Penetrant test, 8″ long
9. Backing removed
10. Seam weld
11. Fillet weld
12. Square groove with 1/8″ root opening
13. J-groove
14. Back or backing
15. Bevel groove

Assignment Sheet 2

Interpret Basic Welding Symbols

1.
    a. Tail
    b. Other side
    c. Arrow side
    d. Reference line
    e. Arrow line

2.
    a. Depth
    b. Broken arrow
    c. Bevel groove
    d. Back or backing weld
    e. See note

3.
    a. Leg size
    b. Length
    c. Pitch
    d. Flush
    e. Machine
    f. Field weld
    g. Fillet weld

Answers to Assignment Sheets

4.
   - a. Depth
   - b. Weld size
   - c. J-groove
   - d. Fillet weld
   - e. Root opening
   - f. Included angle
   - g. Unequal leg
   - h. Specification
   - i. Weld all around

5.
   - a. Diameter
   - b. Plug weld
   - c. Depth of fill
   - d. Pitch
   - e. Included angle
   - f. Gas Metal Arc Welding

Assignment Sheet 3

Interpret Working Welding Symbols

Order may vary, but student answers should contain all of the following:

1. Staggered, intermittent fillet weld.
   Arrow side is $^{3}/_{8}$″ fillet, 2″ length, 8″ pitch.
   Other side is $^{1}/_{2}$″ fillet, 2″ length, 8″ pitch.
   Weld all around. See Spec. E-2.

2. Arrow side $^{1}/_{2}$″ deep V-groove with $^{1}/_{8}$″ root opening.
   65° included angle ground flush.
   Other side, $^{1}/_{16}$″ back weld.

3. Arrow side $^{1}/_{4}$″ deep bevel groove with 30° included angle.
   Unequal leg fillet added, see detail A.
   Broken arrow. Other side, $^{3}/_{8}$″ deep bevel groove with 45° included angle with $^{1}/_{4}$″ fillet added.

4. Arrow side, $^{1}/_{4}$″ deep bevel groove with 25° included angle.
   Chipped flush, welded in the field, broken arrow.
   Other side, $^{1}/_{8}$″ melt through, machined convex.

5. Arrow side, $^{3}/_{16}$″ fillet weld, weld all around.
   Other side, $^{3}/_{8}$″ fillet weld.
   Use gas tungsten arc welding.

6. Arrow side $1^{3}/_{8}$″ diameter plug weld, 6″ pitch.
   60° included angle, machine flush.

7. Arrow side, V-groove with 1/4″ root opening.
Other side, backing removed, machine flush, see Note 2.
Ultrasonic test other side.

8. Other side, 3/16″ deep J-groove with 1/16″ root opening.
20° included angle, machine convex.
Arrow side, melt through, grind flush. Use gas metal arc welding, broken arrow.

9. Both sides, square groove with 1/8″ root opening, welded all around in the field.

10. Arrow side, 1/2″ deep U-groove with 0 (zero) root opening, 65° included angle.
Other side, 3/8″ deep U-groove with 0 (zero) root opening, 65° included angle.

11. Arrow side, 3/16″ diameter resistance projection weld, 10″ pitch, 12 of them.

12. Arrow side, slot weld, see Detail A, depth of fill 1/2″.

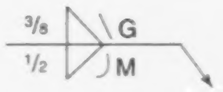
13. Arrow side, 5/16″ deep bevel groove with 1/8″ root opening, 60° included angle, broken arrow.
Other side, square groove with 1/8″ root opening, 3/8″ weld size.

14. Arrow side, 3/8″ deep V-groove, 1/2″ weld size with 1/4″ root opening, 45° included angle, 1/2″ weld size, ground flush.
Other side, back gouge, back weld, ground flush.
Arrow side, radiographic testing.

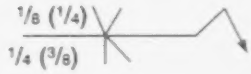
Assignment Sheet 4

Draw Welding Symbols for Given Specifications

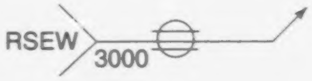
1.



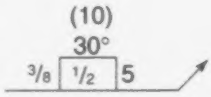
2.



3.

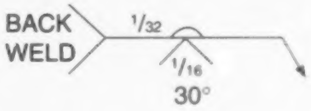


4.

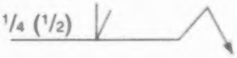


Answers to Assignment Sheets

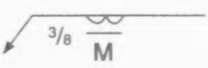
5.


BACK
WELD
1/32
1/16
30°

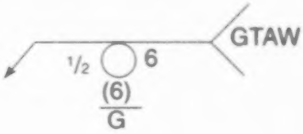
6.



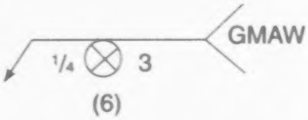
7.



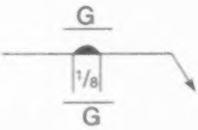
8.



9.



10.



Assignment Sheet 5

Interpret a Welding Print and Welding Procedure Specifications

1. c
2. b
3. c
4. a
5. d
6. b
7. a
8. c
9. d
10. b

Written Test

Name ____

Date ______________________________ Score __________

Objective 1

Match the terms with their definitions.

1. Flush
2. Workpiece
3. Concave
4. Convex
5. Consumable insert
6. Pitch
7. Miter
8. Weld symbol
9. Welding symbol

_____ a. Rounded or curved inward in relation to adjoining planes

_____ b. Preplaced filler metal that is completely fused into the joint root and becomes part of the weld

_____ c. Rounded or curved outward in relation to adjoining planes

_____ d. Forming a relatively level or continuous plane on a surface

_____ e. The part that is welded, brazed, soldered, thermal cut, or thermal sprayed

_____ f. The beveled edges of workpieces made by cutting two pieces at angles and joining them

_____ g. The center-to-center distance between two welds

_____ h. A graphical representation indicating the type of weld required

_____ i. A graphical representation of a weld symbol and other elements applied in standardized notation

Objective 2

Complete statements about basic parts of a welding symbol. Circle the information that best completes each statement.

a. A reference line is a straight line on a horizontal plane with all other welding information located **(above or below) (above, below, or on)** the reference line.

b. Multiple reference lines are used to indicate a sequence of welds or associated activity with the first weld of the series **(closest the arrow) (on the top line)**.

c. An arrow line extends at an angle from **(either end) (the left end)** of a reference line and is terminated with an arrowhead.

d. The arrow may point **(in any direction) (in only one direction)**, but it always points to the welding joint which requires preparation and/or welding.

e. The tail of a welding symbol is at **(the end of) (a selected point on)** a reference line, opposite the arrow and it has the horizontal V-shape of feathers at the end of an arrow.

f. The free space in the tail is used for notes, specifications, process, and other items, but if no instructions are required, **(the tail is still used for on-site additions) (the tail is not used)**.

Objective 3

Complete statements about arrow side, other side significance. Circle the information that best completes each statement.

a. A weld symbol located beneath the reference line indicates the weld is to be made **(on the opposite side the arrow points to) (on the same side the arrow points to)**.

b. A weld symbol located above the reference line indicates the weld is to be made **(on the opposite side the arrow points to) (on the same side the arrow points to)**.

Objective 4

Select true statements about arrow line variations by placing an "X" in the blank next to each true statement.

_____ a. A broken arrow line points to the workpiece to be prepared, and is used only on a bevel, no other joint.

_____ b. Multiple arrow lines are used to indicate that three different welding or cutting processes are required in the same place.

Objective 5

Differentiate between weld symbols and welding symbols. Place an "X" in the blanks next to the definition of a welding symbol.

_____ a. This symbol is a shape designed to represent a basic weld.

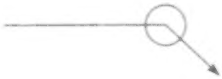
_____ b. This symbol is on the reference line along with all other information significant to the weld.

Objective 6

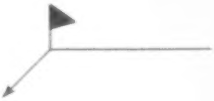
Identify supplementary symbols. Write the number denoting the symbol name beside the appropriate graphic.

1. Backing
2. Melt through
3. Weld all around
4. Spacer
5. Consumable insert
6. Field weld

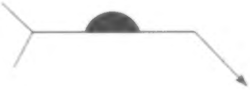
____ a.



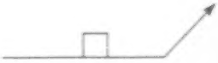
____ b.



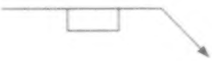
____ c.



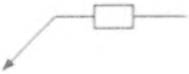
____ d.



____ e.



____ f.

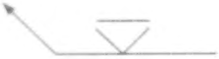


Objective 7

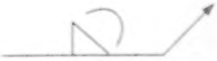
Identify contour and finish symbols. Write the number denoting the symbol name beside the appropriate graphic.

1. Concave contour
2. Finish with grinding
3. Finish with chipping
4. Flush contour
5. Convex contour

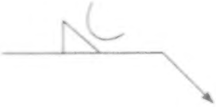
____ a.



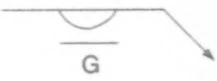
____ b.



____ c.



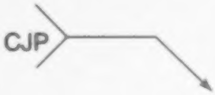
____ d.



Written Test

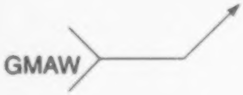
Objective 8

Interpret information in a welding symbol tail. In your own words, state what the following information indicates.



a. ______________________________

____



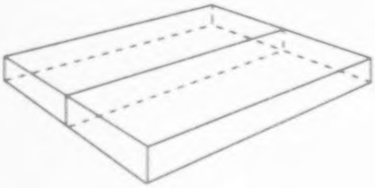
b. ______________________________

____

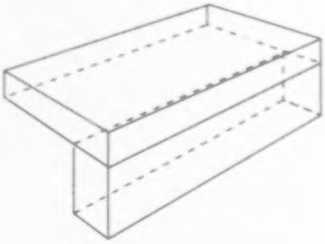
Objective 9

Identify basic welding joints. Write the number denoting the welding joint beside the appropriate graphic. Graphics continue on next page.

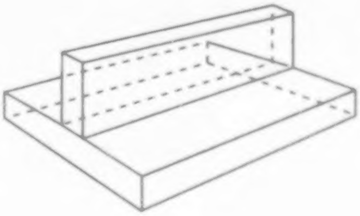
1. T-joint
2. Lap joint
3. Butt joint
4. Edge joint
5. Corner joint



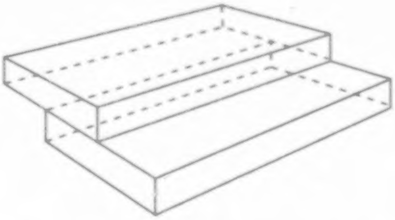
_____ a.



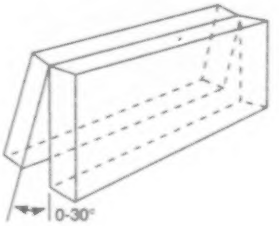
_____ b.



____ c.



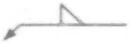
____ d.

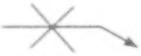


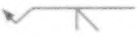
____ e.

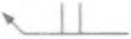
Objective 10

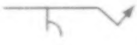
Interpret basic welding symbols. With the following illustrations, write the name of the weld and whether it is arrow side, other side, both sides, or either side, and if additional information applies.

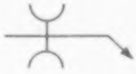
a.  Weld ______________ Added Information ______________

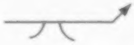
b.  Weld ______________ Added Information ______________

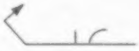
c.  Weld ______________ Added Information ______________

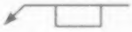
d.  Weld ______________ Added Information ______________

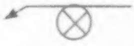
e.  Weld ______________ Added Information ______________

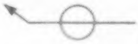
f.  Weld ______________ Added Information ______________

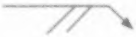
g.  Weld ______________ Added Information ______________

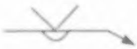
h.  Weld ______________ Added Information ______________

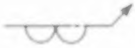
i.  Weld ______________ Added Information ______________

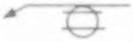
j.  Weld ______________ Added Information ______________

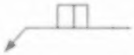
k.  Weld ______________ Added Information ______________

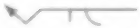
l.  Weld ______________ Added Information ______________

m.  Weld ______________ Added Information ______________

n.  Weld ______________ Added Information ______________

o.  Weld ______________ Added Information ______________

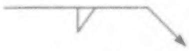
p.  Weld ______________ Added Information ______________

q.  Weld ______________ Added Information ______________

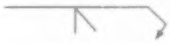
Objective 11

Apply basic rules for locating dimensions. Place the dimensions properly in the following welding symbols.

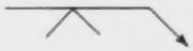
a. Indicate a 1/4″ weld size on a fillet weld welding symbol.



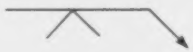
b. Indicate a 1/2″ groove depth on a bevel groove weld welding symbol.



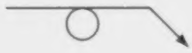
c. Indicate a 5/8″ groove size and a 1/2″ depth of bevel on a v-groove weld welding symbol.



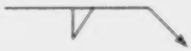
d. Indicate a root opening of 1/8″ and an included angle of 60° on a v-groove weld welding symbol.



e. Indicate that 4 welds should be made on a resistance weld welding symbol.

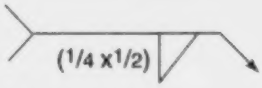


f. Indicate that 4 welds with a 10″ pitch should be made on a fillet weld welding symbol.

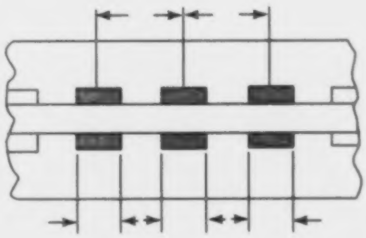


Objective 12 Apply additional dimensioning symbols to fillet welds. Place the dimensions properly in the following welding symbols.

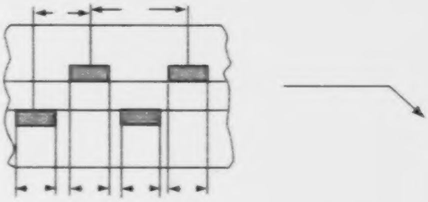
a. Indicate that an unequal leg fillet weld will have a horizontal leg of 1/2″ and a vertical leg of 1/4″ and indicate the information will be shown in Detail A, then create Detail A.



b. Indicate that an intermittent fillet weld will have welds 2″ long with a 5″ pitch.



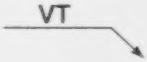
c. Indicate that a staggered-intermittent fillet weld will have welds 3″ long with a 10″ pitch.

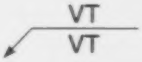


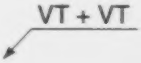
Objective 13

Interpret nondestructive testing symbols. Select the best interpretation for each of the following testing requirements.

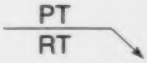
a. A fillet weld should be visually tested on both sides.

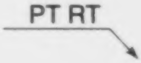
(1)


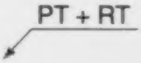
(2)


(3)


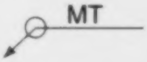
b. A groove weld requires penetrant testing and radiographic testing.

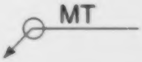
(1)


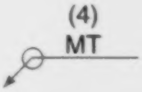
(2)


(3)


c. A fillet weld on a pipe requires magnetic particle testing in four specific or random locations.

(1)


(2)


(3)


Objective 14

Select true statements about procedures for fitting up and welding structural shapes by placing an "X" in the blank next to each true statement.

_____ a. Structural shapes of the same or different sizes may be butted for fit-up and welding.

_____ b. Structural shapes of only the same sizes may be mitered for fit-up and welding.

_____ c. Structural shapes of the same or different sizes may be notched for fit-up and welding.

*Permission to duplicate this test is granted.

Answers to Written Test

Objective 1

a. 3
b. 5
c. 4
d. 1
e. 2
f. 7
g. 6
h. 8
i. 9

Objective 2

a. Above, below, or on
b. Closest the arrow
c. Either end
d. In any direction
e. The end of
f. The tail is not used

Objective 3

a. On the same side the arrow points to
b. On the opposite side the arrow points to

Objective 4

Both a and b are false

Objective 5

b

Objective 6

a. 3
b. 6
c. 2
d. 5
e. 1
f. 4

Objective 7

a. 4
b. 5
c. 1
d. 2

Objective 8

Answers should approximate those given:

a. Calls for complete joint penetration of the weld
b. Calls for gas metal arc welding process

Objective 9

a. 3
b. 5
c. 1
d. 2
e. 4

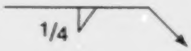
Answers to Written Test

Objective 10

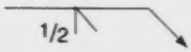
a. Fillet, other side
b. V-groove, both sides
c. Bevel groove, arrow side, broken arrow
d. Square groove, other side
e. J-groove, arrow side, broken arrow
f. U-groove, both sides
g. Flare V, arrow side
h. Flare bevel, other side, broken arrow
i. Plug or slot, arrow side
j. Stud, arrow side
k. Spot or projection, nor arrow or other side significance
l. Scarf, arrow side
m. V-groove with back or backing, arrow side
n. Surfacing, arrow side
o. Seam, arrow side
p. Edge flange, other side
q. Flare-bevel , arrow side, broken arrow

Objective 11

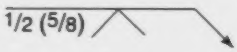
a.



b.



c.



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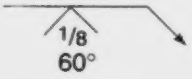

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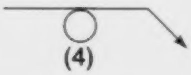

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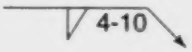
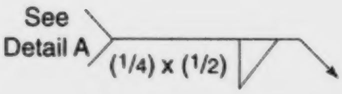
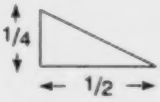


Objective 12

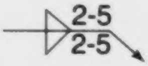
a.



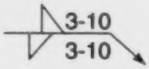
Detail A



b.



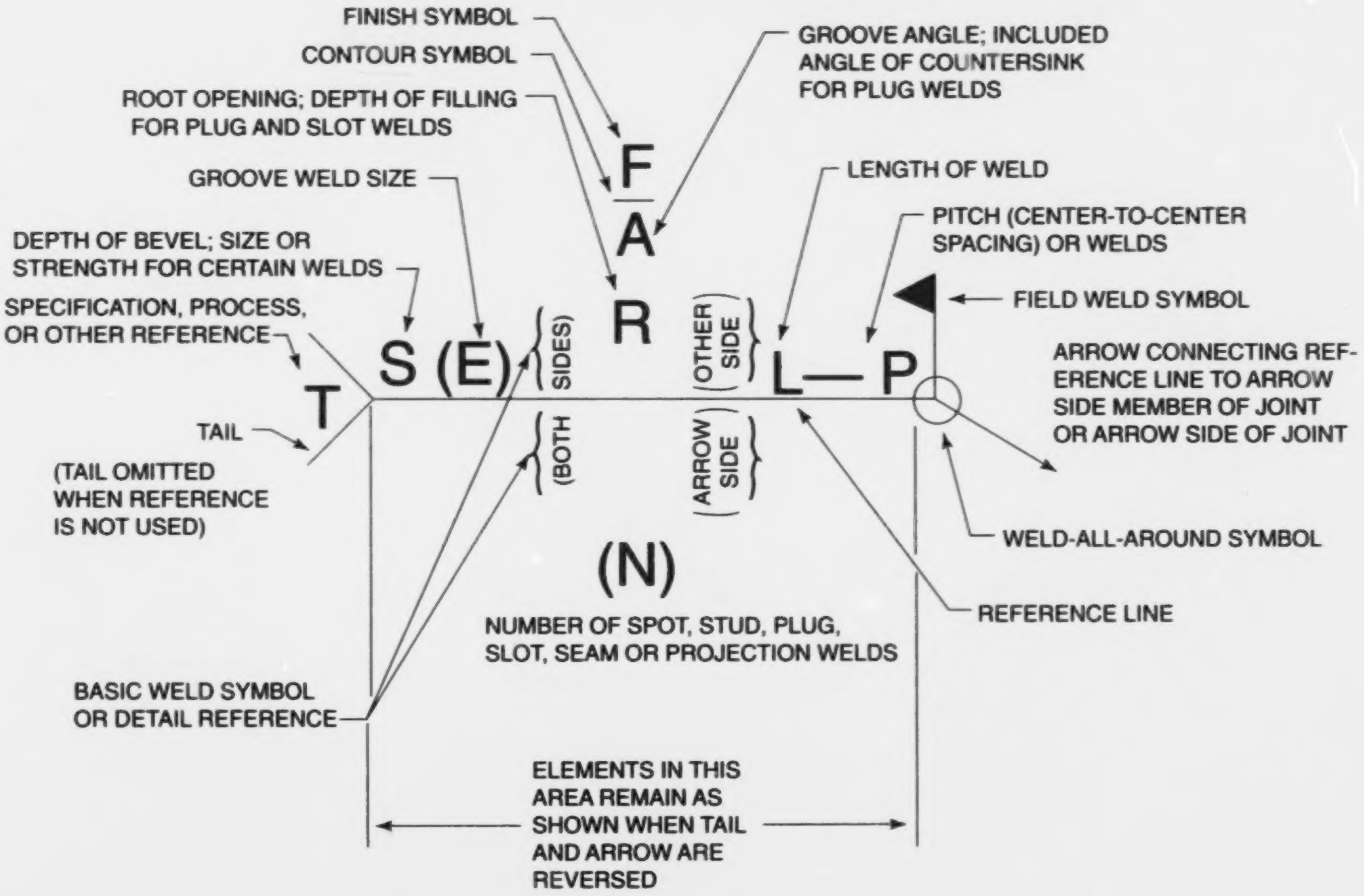
c.



Answers to Written Test

Objective 13	a. 2 b. 3 c. 3
Objective 14	a, c

Parts of a Welding Symbol



FINISH SYMBOL

CONTOUR SYMBOL

ROOT OPENING; DEPTH OF FILLING FOR PLUG AND SLOT WELDS

GROOVE WELD SIZE

DEPTH OF BEVEL; SIZE OR STRENGTH FOR CERTAIN WELDS

SPECIFICATION, PROCESS, OR OTHER REFERENCE

TAIL

(TAIL OMITTED WHEN REFERENCE IS NOT USED)

BASIC WELD SYMBOL OR DETAIL REFERENCE

GROOVE ANGLE; INCLUDED ANGLE OF COUNTERSINK FOR PLUG WELDS

LENGTH OF WELD

PITCH (CENTER-TO-CENTER SPACING) OR WELDS

FIELD WELD SYMBOL

ARROW CONNECTING REFERENCE LINE TO ARROW SIDE MEMBER OF JOINT OR ARROW SIDE OF JOINT

WELD-ALL-AROUND SYMBOL

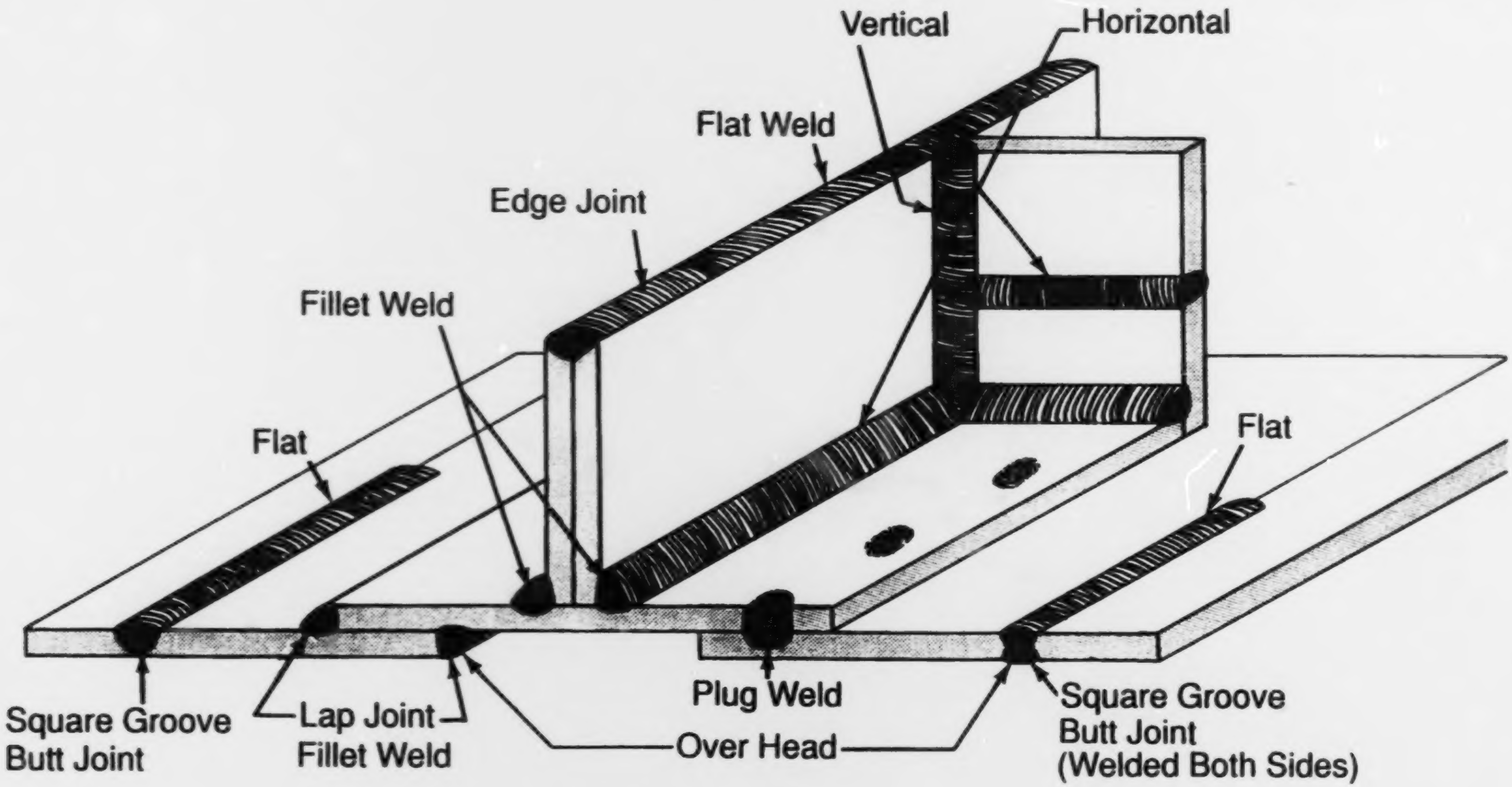
REFERENCE LINE

NUMBER OF SPOT, STUD, PLUG, SLOT, SEAM OR PROJECTION WELDS

ELEMENTS IN THIS AREA REMAIN AS SHOWN WHEN TAIL AND ARROW ARE REVERSED

Courtesy American Welding Society

Typical Welded Joints and Positions


Vertical
Horizontal
Flat Weld
Edge Joint
Fillet Weld
Flat
Flat
Square Groove Butt Joint
Lap Joint Fillet Weld
Plug Weld
Over Head
Square Groove Butt Joint (Welded Both Sides)

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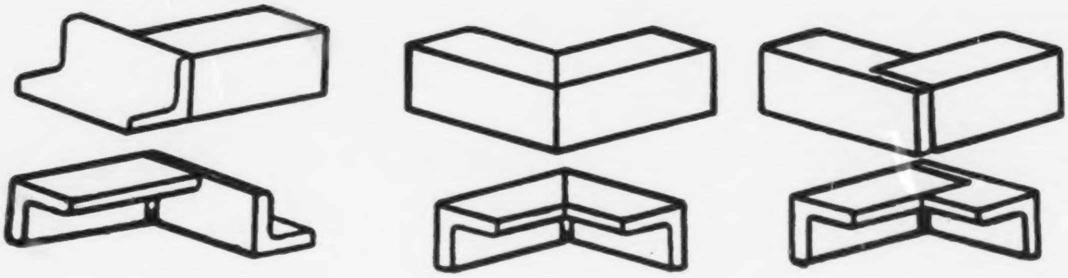
Welding Angle to Angle



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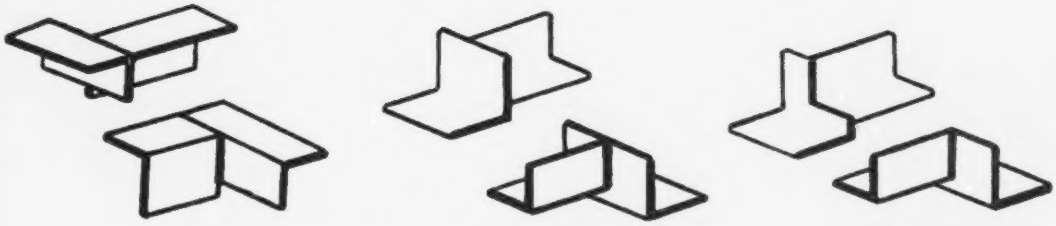
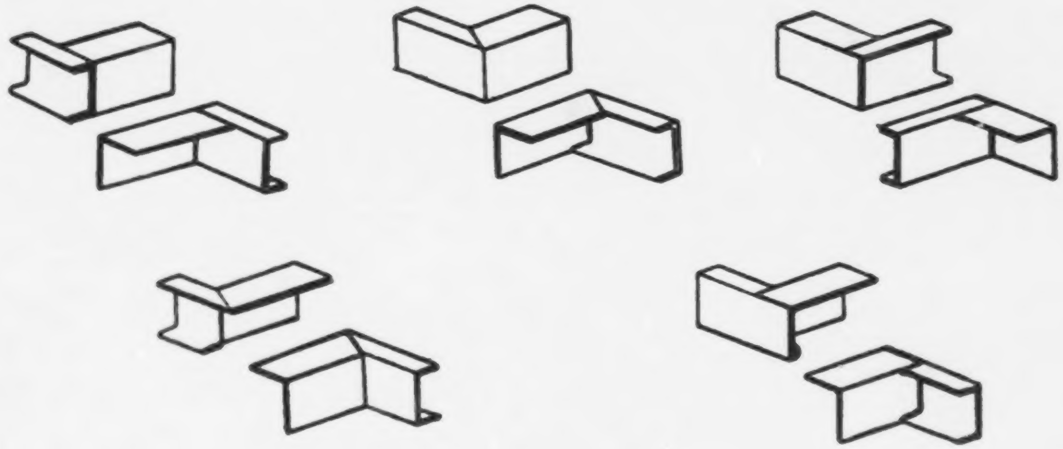


Different Sizes

Courtesy Lincoln Electric Company

Welding Angle to Channel



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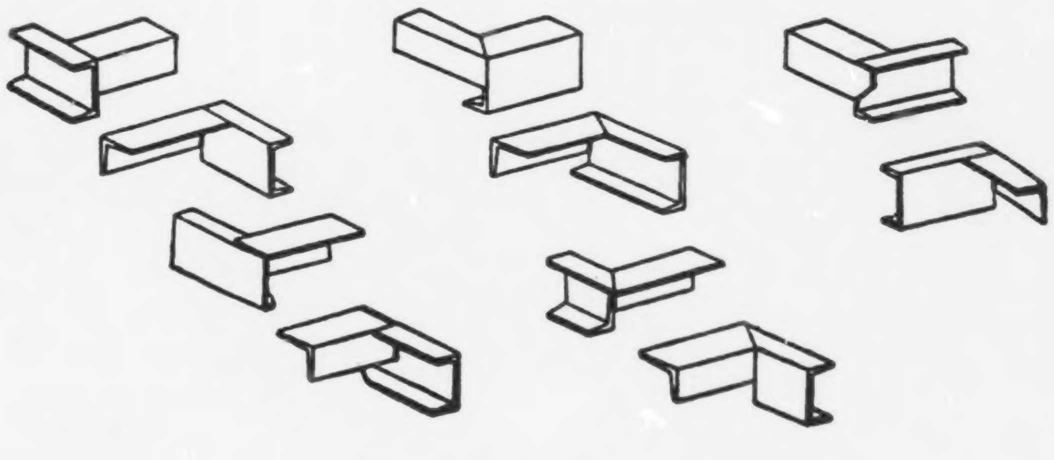
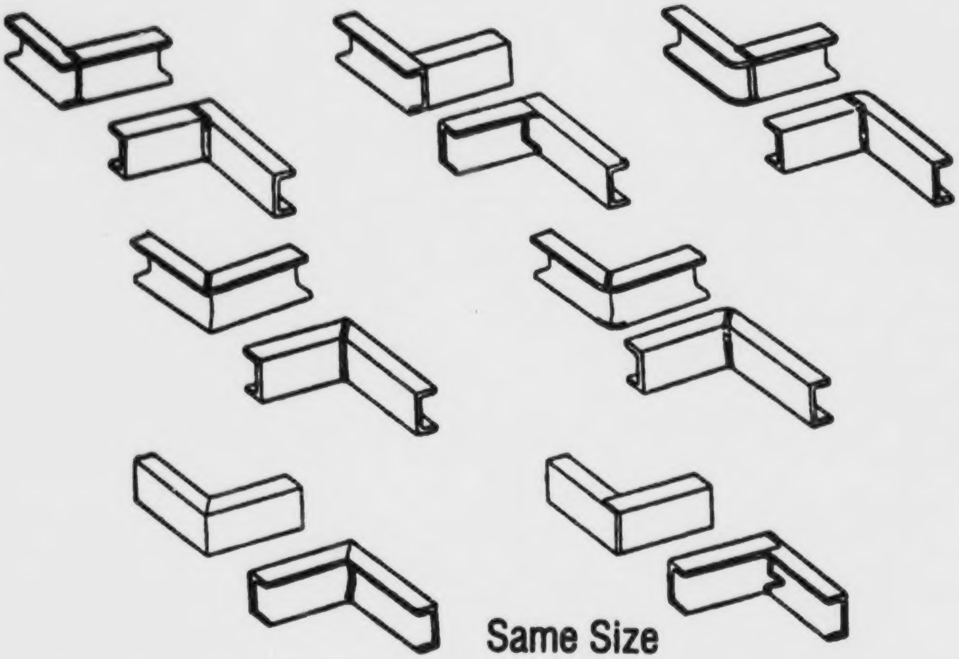


Different Sizes

Courtesy Lincoln Electric Company

Welding Channel to Channel



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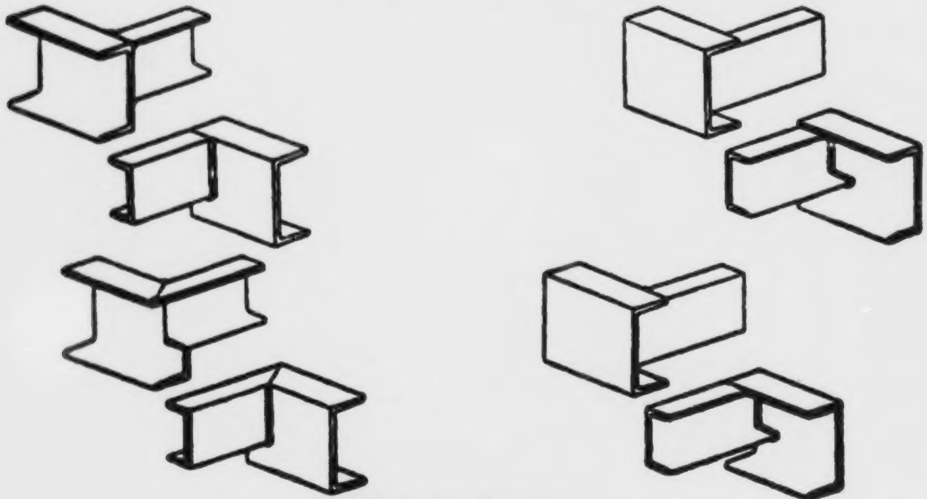
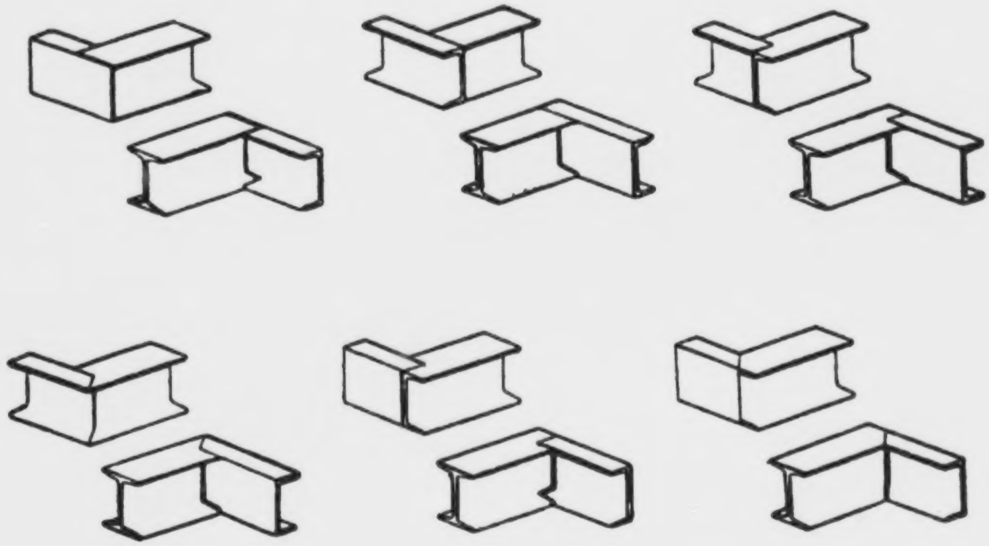


Different Sizes

Courtesy Lincoln Electric Company

Welding Channel to S or W Beams



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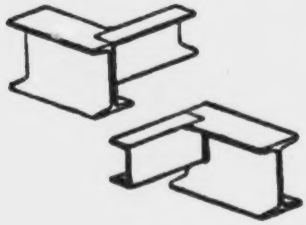
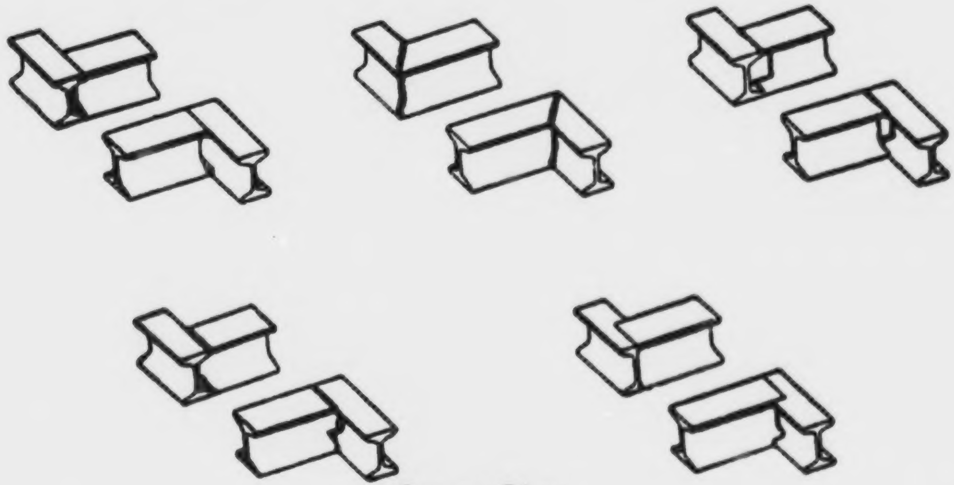


Different Sizes

Courtesy Lincoln Electric Company

Welding S Beams to W or W to S Beams



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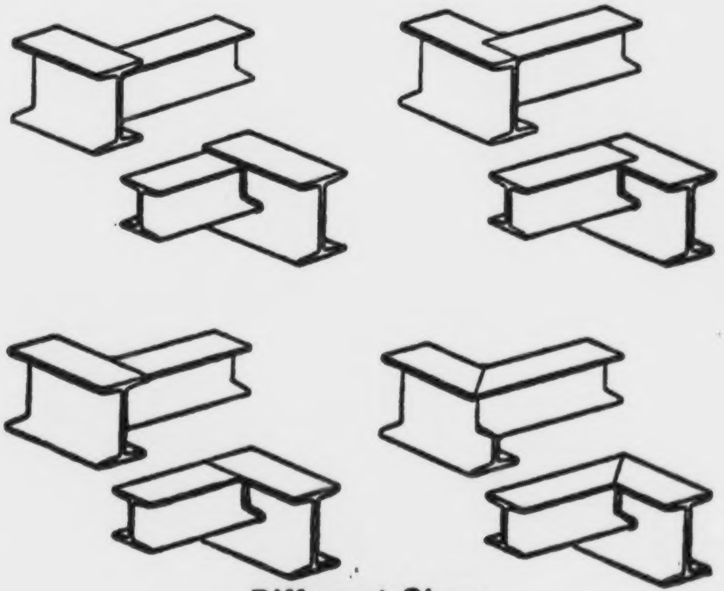
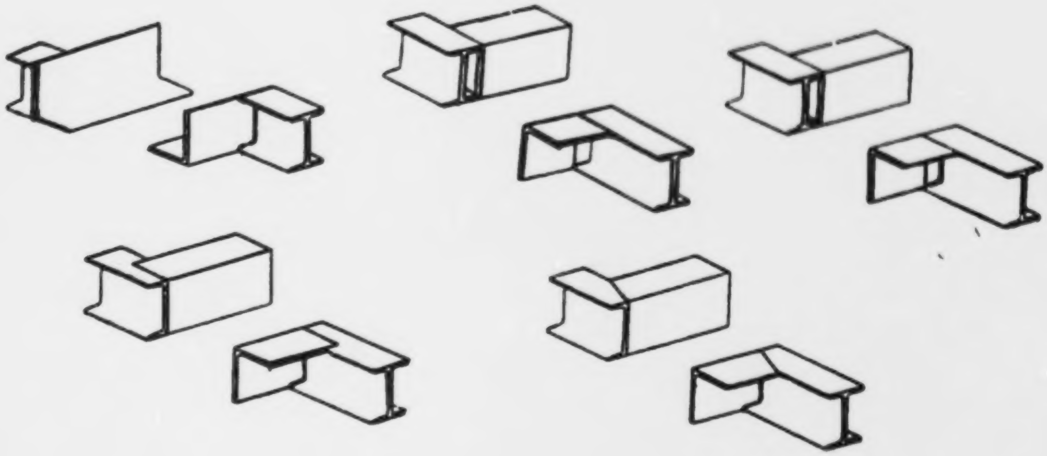


Different Sizes

Courtesy Lincoln Electric Company

Welding Angle to S or W Beams



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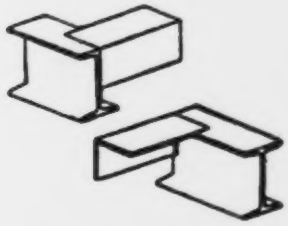
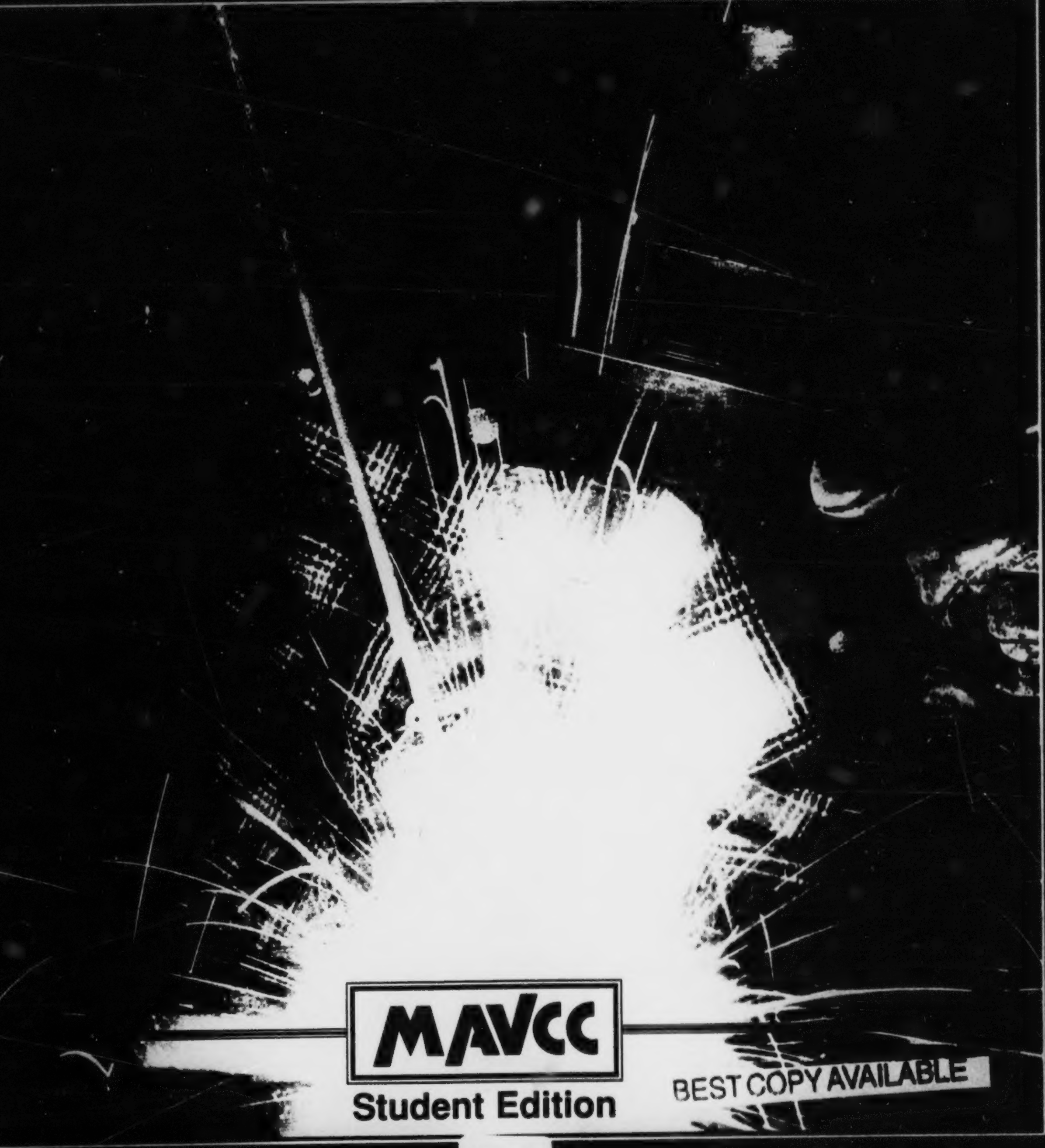


Different Sizes

Courtesy Lincoln Electric Company

Fundamentals of Welding

Second Edition



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Student Edition

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Fundamentals of Welding

Second Edition

Student Edition

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Project coordinated by

Glenn Fleming

Developed by

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Unit 7: Welding Print Reading

Unit 8: Basic Welding Joints and Symbols

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Student Edition

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Objective Sheet 1–5
Information Sheet 1–7

Student Workbook

*Assignment Sheets

1—Identify Welding Processes 1
2—Compare Employment Opportunities in Welding 3

*Assignment Sheets are located in the Student Workbook.

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Prerequisites:
None

Learning Activities Sheet

Student Name ____________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

Optional

☐ 3. **View** Videotape entitled "Welding: Making It Happen."

☐ 4. **Research** Online resources regarding welding products and services. Visit www.aws.org (American Welding Society) as one of your resources.

☐ 5. **Study** Information Sheet, Objectives 1 and 2.

☐ 6. **Do** Assignment Sheet 1, "Identify Welding Processes."

☐ 7. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 8. If the evaluation is not satisfactory, repeat Steps 5 and 6.

☐ 8. **Study** Information Sheet, Objectives 3 through 9.

Optional

☐ 9. **View** Videotape entitled "Welding as a Career."

☐ 10. **Research** Online resources regarding general occupational information. Visit www.bls.gov (Occupation Outlook Handbook) as one of your resources.

☐ 11. **Do** Assignment Sheet 2, "Compare Employment Opportunities in Welding."

☐ 12. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 13. If the evaluation is not satisfactory, repeat Steps 8 through 11.

☐ 13. **Study** Information Sheet, Objectives 10 and 11.

Learning Activities Sheet

☐ 14. **Check** With instructor for any additional assignments to be completed.

☐ 15. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 16. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Objective Sheet

Unit Objective

After completing this unit, the student should be able to discuss the importance of welding and cutting processes and identify common welding processes. The student should demonstrate these competencies by completing the assignment sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Define terms related to welding orientation.
2. Complete statements about welding processes.
3. Select true statements about brazing and braze welding.
4. Complete statements about cutting processes.
5. Select true statements about where welders work.
6. Complete statements about what welders earn.
7. Select true statements about the job outlook for welders.
8. Complete statements about what it takes to become a good welder.
9. Select career opportunities for welders.
10. Match the terms standard, code, and specification to their definitions.
11. Complete statements about standards and their importance to the welding industry.

*12. Identify welding processes. (Assignment Sheet 1)

*13. Compare employment opportunities in welding. (Assignment Sheet 2)

*Assignment Sheets are located in the Student Workbook.

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Information Sheet

Objective 1

Terms and definitions

a. **Base metal**—The metal or alloy that is welded, brazed, soldered, or cut

b. **Coalescence**—The growing together or growth into one body of the materials being welded

c. **Fusion welding**—The melting together of filler metal and base metal, or of base metal only, to produce a weld

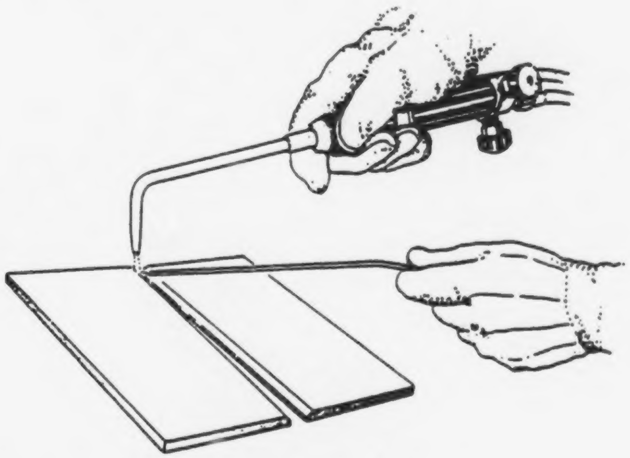
d. **Welding**—A joining process that produces coalescence of materials by heating to a melting point, with or without the application of pressure and with or without the use of filler metal

Objective 2

Welding processes and their applications

a. Oxyfuel Gas Welding (OFW)—A group of welding processes that produces coalescence by heating materials with an oxyfuel gas flame or flames, with or without pressure, and with or without the use of filler material

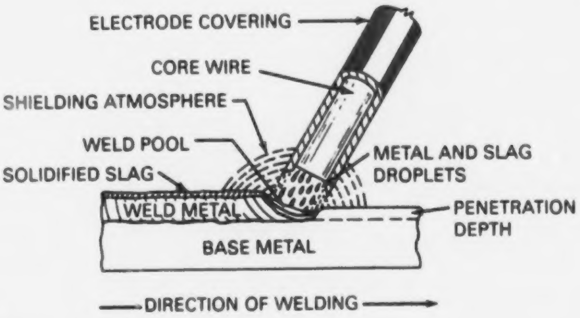
Figure 1



Courtesy Union Carbide Corporation, Linde Division

b. Shielded Metal Arc Welding (SMAW)—An arc welding process that produces coalescence of materials by heating them with an arc between a covered electrode and a workpiece; shielding is obtained from decomposition of the electrode cover, pressure is not used, and filler metal is obtained from the electrode

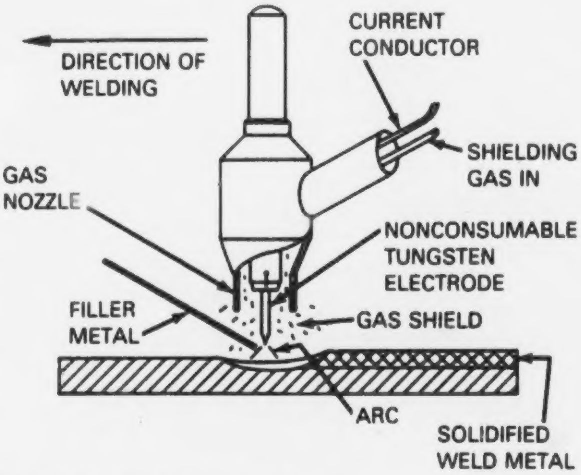
Figure 2


ELECTRODE COVERING
CORE WIRE
SHIELDING ATMOSPHERE
WELD POOL
SOLIDIFIED SLAG
METAL AND SLAG DROPLETS
WELD METAL
PENETRATION DEPTH
BASE METAL
DIRECTION OF WELDING

Courtesy American Welding Society

c. Gas Tungsten Arc Welding (GTAW)—An arc welding process that produces coalescence of materials by heating them with an arc between a nonconsumable tungsten electrode and a workpiece; shielding is obtained from a gas, and filler metal may or may not be used

Figure 3


DIRECTION OF WELDING
CURRENT CONDUCTOR
SHIELDING GAS IN
GAS NOZZLE
NONCONSUMABLE TUNGSTEN ELECTRODE
FILLER METAL
GAS SHIELD
ARC
SOLIDIFIED WELD METAL

Courtesy American Welding Society

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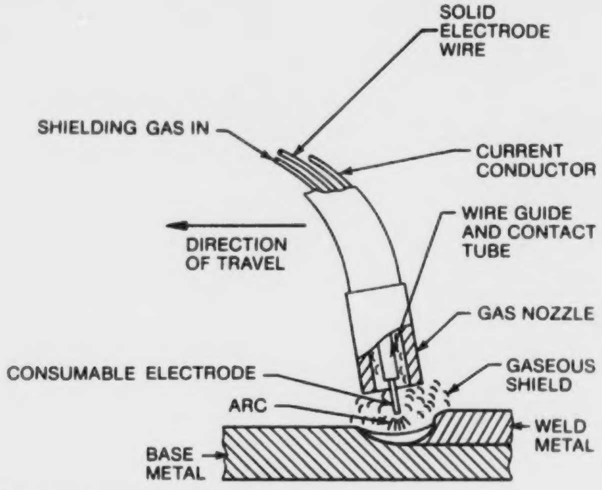
d. Gas Metal Arc Welding (GMAW)—An arc welding process that produces coalescence of metals by heating them with an arc between a continuous filler metal electrode and a workpiece; shielding is obtained entirely from an externally supplied gas

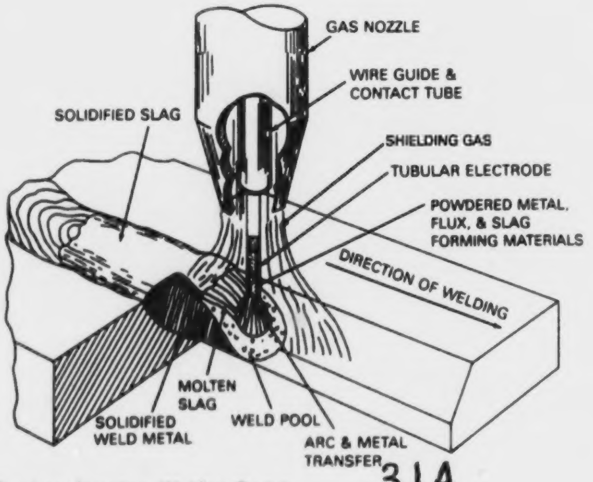
Figure 4


SOLID ELECTRODE WIRE
SHIELDING GAS IN
CURRENT CONDUCTOR
DIRECTION OF TRAVEL
WIRE GUIDE AND CONTACT TUBE
GAS NOZZLE
CONSUMABLE ELECTRODE
GASEOUS SHIELD
ARC
WELD METAL
BASE METAL

Courtesy American Welding Society

e. Flux-Cored Arc Welding (FCAW)—An arc welding process that produces coalescence of metals by heating them with an arc between a continuous filler metal electrode and a workpiece; shielding is provided by a flux contained within the tubular electrode, and additional shielding may or may not be obtained from an externally supplied gas or gas mixture

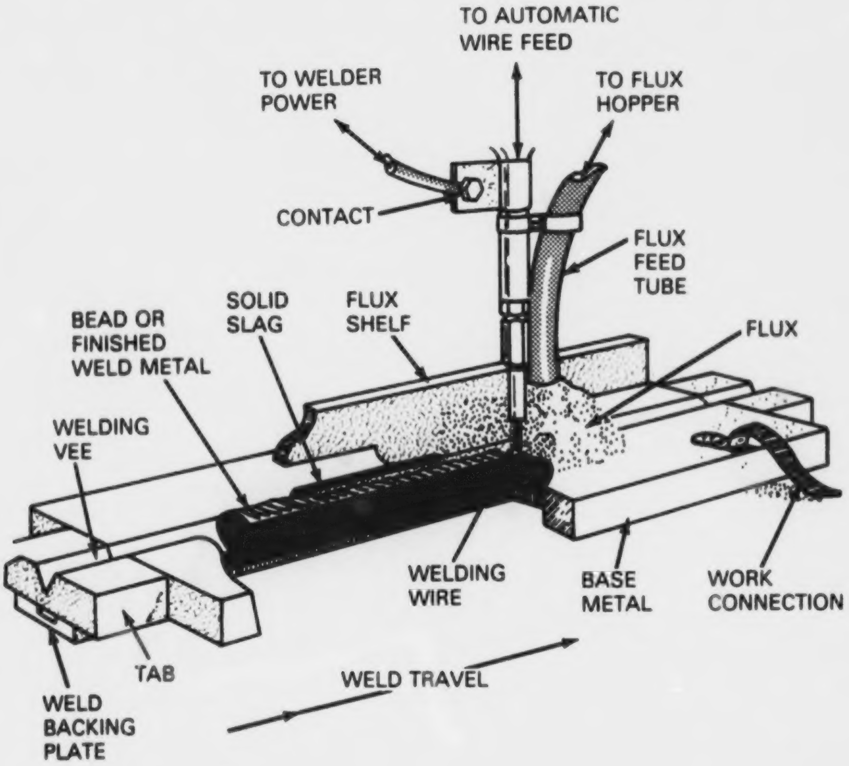
Figure 5


GAS NOZZLE
WIRE GUIDE & CONTACT TUBE
SOLIDIFIED SLAG
SHIELDING GAS
TUBULAR ELECTRODE
POWDERED METAL, FLUX, & SLAG FORMING MATERIALS
DIRECTION OF WELDING
MOLTEN SLAG
SOLIDIFIED WELD METAL
WELD POOL
ARC & METAL TRANSFER

Courtesy American Welding Society

f. Submerged Arc Welding (SAW)—An arc welding process that produces coalescence of metals by heating them with an arc or arcs between a bare metal electrode or electrodes and a workpiece; the arc and molten metal are shielded by a blanket of granular, fusible material on the workpiece; pressure is not used, and filler metal is obtained from the electrode or sometimes from a supplemental source

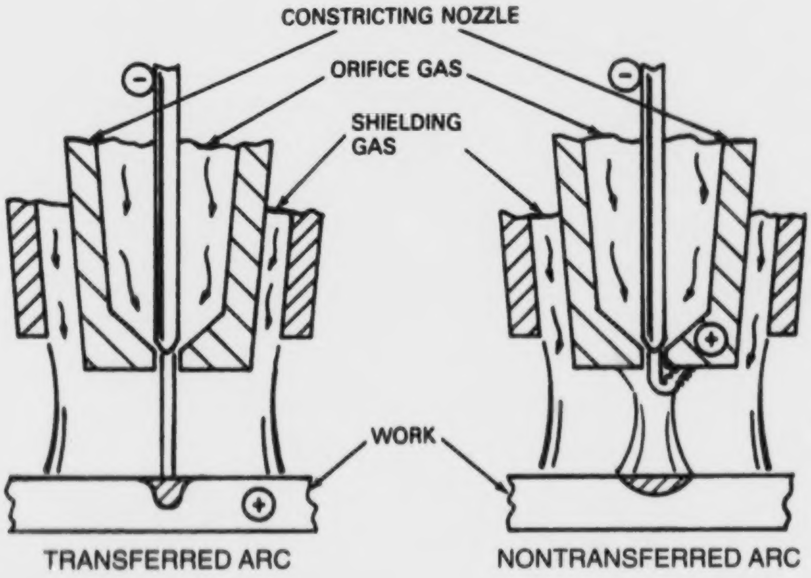
Figure 6


TO AUTOMATIC WIRE FEED
TO WELDER POWER
TO FLUX HOPPER
CONTACT
FLUX FEED TUBE
SOLID SLAG
FLUX SHELF
BEAD OR FINISHED WELD METAL
FLUX
WELDING VEE
WELDING WIRE
BASE METAL
WORK CONNECTION
TAB
WELD TRAVEL
WELD BACKING PLATE

Courtesy American Welding Society

g. Plasma Arc Welding (PAW)—An arc welding process that produces coalescence of metals by heating them with a constricted arc between a nonconsumable electrode and a workpiece (transferred arc), or the electrode and a constricting nozzle (nontransferred arc)

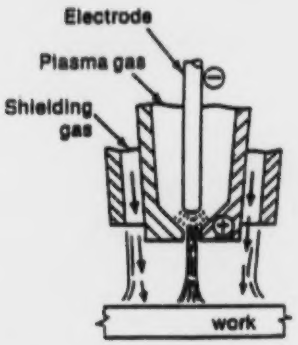
Figure 7


CONSTRICTING NOZZLE
ORIFICE GAS
SHIELDING GAS
WORK
TRANSFERRED ARC
NONTRANSFERRED ARC

Courtesy American Welding Society

h. In PAW, shielding is obtained from the hot, ionized gas issuing from the torch, and this may be supplemented with an auxiliary source of shielding gas; shielding gas may be an inert gas or a mixture of gases, and filler metal may or may not be used

Figure 8


Electrode
Plasma gas
Shielding gas
work

Courtesy Lincoln Electric Company

Objective 3

Brazing and braze welding

a. Brazing is a group of welding processes that produces coalescence of materials by heating them to the brazing temperature in the presence of a filler metal having a melting point above 840°F and below the melting point of the base metal.

b. In brazing processes, the filler metal is distributed between the closely fitted surfaces of the joint by capillary action.

c. Braze welding is a welding process variation that uses a filler metal with a melting point above 840°F and below the melting point of the base metal.

d. Unlike brazing, in braze welding, the filler metal is not distributed in the joint by capillary action.

Objective 4

Cutting processes

a. Oxyfuel Gas Cutting (OFC)—A group of cutting processes used to sever metals by means of the chemical reaction of oxygen with a base metal at elevated temperatures; the necessary temperature is maintained by means of gas flames obtained from the combustion of a specified fuel gas and oxygen

Note: The oxyfuel cutting processes include oxyacetylene, OFC-A; oxyhydrogen, OFC-H; oxynatural, OFC-N; oxypropane, OFC-P; and others.

b. Carbon Arc Cutting (CAC)—A group of cutting processes that sever or remove metal by melting with the heat of the arc between an electrode and the workpiece

Note: Some popular arc cutting processes are carbon arc cutting-air (CAC-A) and plasma arc cutting (PAC). These processes are discussed in other texts of the MAVCC welding series.

Objective 5

Where welders work

a. Welders, cutters, and welding machine operators held about 453,000 jobs in 1996.

b. About 9 out of 10 welders and cutters were employed in manufacturing, services, construction, or wholesale trade.

c. The majority of those in manufacturing were employed in transportation equipment, industrial machinery and equipment, or fabricated metal products.

d. All welding machine operators were employed in manufacturing industries, primarily fabricated metal products, machinery, and motor vehicles.

Objective 6

What welders earn

a. The median earning for welders and welding machine operators was about $478 a week in 1996.

Note: Figures are from the Bureau of Labor Statistics for the late 1990s.

b. Beginners and lesser paid welders averaged $278 a week, but welders in the top 10 percent income bracket earned over $807 a week.

c. Many welders work in situations where company benefits make the job more attractive, and over one-fourth of all welders belong to a union.

Note: Some of the unions that welders find attractive are the International Association of Machinists and Aerospace Workers; the International Brotherhood of Boilermakers, Iron Ship Builders, Blacksmiths, Forgers and Helpers; United Automobile Workers, Aerospace and Agricultural Implement Workers of America; United Association of Journeymen and Apprentices of the Plumbing and Pipe Fitting Industry of the United States and Canada; and the United Electrical, Radio, and Machine Workers of America.

Objective 7

Job outlook for welders

a. Employment of welders and cutters is expected to increase by 8.3% from 1998 through the year 2008.

b. In some areas, the need for welders will decline through the year 2008 but many job openings will arise because of the need to replace experienced workers who transfer or retire.

c. The areas that look best for good welding jobs are in construction and business services (repair) because these are areas that are difficult to automate.

d. Many jobs will be open in manufacturing, but they will be jobs in maintenance, repair, and other areas where the work cannot be automated.

Objective 8

What it takes to become a good welder

a. Training for welding should start early in high school and include courses in shop math, mechanical drawing, print reading, physics, chemistry, and metallurgy. If available, take applied courses in the preceding courses; take applied physics instead of traditional physics.

b. Some welding machine operators can learn their jobs in a few days or weeks, but employers prefer applicants who have high school, vocational and/or postsecondary training in welding.

c. Welders and cutters need manual dexterity, good eyesight, and good eye-hand coordination.

d. Good welders should also be able to concentrate on detailed work for long periods, and be able to bend, stoop, and work in awkward positions.

Objective 9

Career opportunities for welders

a. The welding machine operator or robotic cell operator will probably take a specialized course to learn the equipment and work in a manufacturing facility that uses automated equipment.

b. The combination welder will normally be found in plant maintenance or a repair shop, and because combination welders can do it all, they are often in demand.

c. The welder-fitter is something of a specialist and works in manufacturing jobs that require a knowledge of metallurgy and joint design in addition to welding skills.

d. The specialist welder will become highly skilled in one or two welding processes and work on special products or projects.

Example: The gas tungsten arc process on stainless steel is a popular process for making bright, shiny salad bars and other restaurant equipment, and is also used frequently with stainless steel applications in medical installations.

e. Welders who demonstrate leadership ability often advance to a supervisory position and may run a welding crew or supervise welders in a facility.

f. Other advanced jobs open to skilled welders include:

(1) Certified welding inspector (CWI);
(2) Welding tester;
(3) Equipment salesperson;
(4) Sales troubleshooter;
(5) Certified welding educator (CWE)

g. Welders who continue their education can advance to the level of welding engineer, metallurgist, or several other jobs where associate or advanced college degrees are required.

Objective 10

Standards, codes, and specifications

a. Standard—A document that governs and guides welding activities

- Describes the technical requirements for a material, process, product, system, or service
- Indicates the procedures, methods, equipment, or tests used to determine that requirements have been met

Note: Standards keep the welder safe and hold them accountable for the work they accomplish.

b. Code—A type of standard that uses the words *shall* and *will* to indicate the mandatory use of certain materials or actions, or both

- Generally associated with a process

c. Specification—A type of standard that uses the words *shall* and *will* to indicate the mandatory use of certain materials or actions, or both

- Generally associated with a product

Objective 11

Standards and their importance to the welding industry

a. In 1936, the Committee on Standard Qualification Procedures issued its first report to the American Welding Society; the report called for general qualification standards for procedures and performances of welders.

b. Today, standards guide many industrial producers, and standards affecting welding are produced by other groups who have welding minimums that must be met and procedures that must be followed.

Note: Standards include codes, specifications, recommended practices, classifications, methods, and guides.

Examples: The American Petroleum Institute sets standards for pipeline welding, the American Society of Mechanical Engineers, among others, sets standards for high pressure boilers, and the Aluminum Association sets standards for welding aluminum.

c. The American Welding Society has various committees who meet to update and change standards as needs require, and among these standards, three are important to all welders, including beginners:

(1) Standard for Welding Procedure and Performance Qualification
(2) Standards Symbols for Welding, Brazing, and Nondestructive Examination
(3) Standard Welding Terms and Definitions

Note: The standards for symbols and terms are not only AWS standards, they are also American National Standards adapted by the American National Standards Institute, ANSI.

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2—Interpret a Material Safety Data Sheet 7
3—Draw a Layout of Your School and Apply the Safety Color Code 13
4—Determine Correct Fire Extinguishers to Use for Various Situations 15
5—Identify and Correct Safety Violations 17

*Job Sheets

1—Operate a Fire Extinguisher 19
2—Lift a Heavy Object Properly 21
3—Place and Climb a Ladder Safely 23

*Assignment and Job Sheets are located in the Student Workbook.

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Prerequisites:
None

Learning Activities Sheet

Student Name ____

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet

☐ 3. **Study** Information Sheet, Objectives 1, 2, and 3.

☐ 4. **Do** Assignment Sheet 1, "Complete the Student Safety Pledge."

☐ 5. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 6. If the evaluation is not satisfactory, repeat Steps 3 and 4.

Optional ☐ 6. **View** Videotape entitled "Hearing Conservation."

Optional ☐ 7. **Research** Online resources regarding OSHA safety and health standards. Visit www.osha.gov as one of your resources.

☐ 8. **Study** Information Sheet, Objective 4.

Optional ☐ 9. **View** Videotape entitled: "Hazard Communication - Your Right to Know."

☐ 10. **Study** Information Sheet, Objectives 5 and 6.

☐ 11. **Read** Student Supplement 1, "Guidelines for Interpreting Material Safety Data Sheets."

☐ 12. **Do** Assignment Sheet 2, "Interpret a Material Safety Data Sheet."

☐ 13. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 14. If the evaluation is not satisfactory, repeat Steps 10, 11, and 12.

Learning Activities Sheet

	☐	14.	**Study**	Information Sheet, Objectives 7, 8, and 9.
	☐	15.	**Do**	Assignment Sheet 3, "Draw a Layout of Your School Shop and Apply the Safety Color Code."
	☐	16.	**Stop**	Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 17. If the evaluation is not satisfactory, repeat Steps 14 and 15.
	☐	17.	**Study**	Information Sheet, Objectives 10 through 14.
📖	☐	18.	**Read**	Student Supplement 2, "Using Portable Fire Extinguishers."
Optional 📼	☐	19.	**View**	Videotape entitled: "Fire Extinguisher Training and Use 2000."
	☐	20.	**Do**	Assignment Sheet 4, "Determine Correct Fire Extinguishers to Use for Various Situations."
	☐	21.	**Stop**	Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 22. If the evaluation is not satisfactory, repeat Steps 18 and 20.
	☐	22.	**Do**	Job Sheet 1, "Operate a Fire Extinguisher."
	☐	23.	**Stop**	Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 24. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 1 and repeat Step 22.
	☐	24.	**Study**	Information Sheet, Objectives 15 and 16.
Optional 📼	☐	25.	**View**	Videotape entitled: "Back Injury Prevention - Safe Lifting."
	☐	26.	**Do**	Job Sheet 2, "Lift a Heavy Object Properly."
	☐	27.	**Stop**	Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 28. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 2 and repeat Step 26.
	☐	28.	**Study**	Information Sheet, Objective 17.
Optional 📼	☐	29.	**View**	Videotape entitled: "How to Prevent Slips, Trips, and Falls."

☐ 30. **Study** Information Sheet, Objective 18.

Optional 📼 ☐ 31. **View** Videotape entitled: "Ladder Safety."

☐ 32. **Do** Job Sheet 3, "Place and Climb a Ladder Safely."

☐ 33. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 34. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 3 and repeat Step 32.

☐ 34. **Study** Information Sheet, Objective 19.

Optional 📼 ☐ 35. **View** Videotape entitled: "OSHA's Hazardous Energy Source-Lockout/Tagout."

☐ 36. **Study** Information Sheet, Objective 20.

Optional 📼 ☐ 37. **View** Videotape entitled: "Fall Protection."

☐ 38. **Study** Information Sheet, Objective 21.

Optional 📼 ☐ 39. **View** Videotape entitled: "Confined Space Entry."

☐ 40. **Study** Information Sheet, Objective 22.

Optional 📼 ☐ 41. **View** Videotape entitled: "HAZWOPER: Respiratory Protection."

☐ 42. **Do** Assignment Sheet 5, "Identify and Correct Safety Violations."

☐ 43. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 44. If the evaluation is not satisfactory, review all unit objectives and repeat step 42.

☐ 44. **Check** With instructor for any additional assignments to be completed.

☐ 45. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 46. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next Learning Activities Sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Objective Sheet

Unit Objective

After completing this unit, the student should be able to identify hazardous job conditions and practice good work and shop safety. The student should demonstrate these competencies by completing the assignment sheets and job sheets, and by scoring a 100 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to general safety with their definitions.
2. Complete guidelines for dressing safely on the job.
3. Select true general job and shop safety rules.
4. Complete statements concerning hazard communication.
5. Complete statements concerning the storage of hazardous materials.
6. Select words to complete facts about the purposes of material safety data sheets (MSDS).
7. Match the colors of the safety color code with their uses.
8. Match safety tags with their color coding.
9. Match accident prevention signs with their colors and uses.
10. List the components of the fire triangle.
11. Match types of fires with their classifications.
12. Match general types of fire extinguishers with their uses.
13. Match fire extinguisher markings to the class of fire they represent.
14. Complete fire extinguisher general operating instructions that follow the letters P-A-S-S.
15. Match causes of back injuries with their contributing factors.
16. Select words to complete guidelines for lifting and moving items safely.
17. List guidelines for preventing slips, trips, and falls.
18. Select words to complete rules for using ladders safely.
19. List instances when lockout devices should be used.
20. List three types of fall protection systems.

21. Match terms related to confined space entry to their characteristics.

22. List environmental contaminants that would require you to use a respirator.

*23. Complete the student safety pledge form. (Assignment Sheet 1)

*24. Interpret a Material Safety Data Sheet. (Assignment Sheet 2)

*25. Draw a layout of your school and apply the safety color code. (Assignment Sheet 3)

*26. Determine correct fire extinguishers to use for various situations. (Assignment Sheet 4)

*27. Identify and correct safety violations. (Assignment Sheet 5)

*28. Operate a fire extinguisher. (Job Sheet 1)

*29. Lift a heavy object properly. (Job Sheet 2)

*30. Place and climb a ladder safely. (Job Sheet 3)

*Assignment and Job Sheets are located in the Student Workbook.

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Information Sheet

Objective 1

Terms and definitions

a. **Accident**—Suddenly occurring, unintentional event that causes injury or property damage

b. **Carelessness**—Failure to think before one acts; failure to pay attention

c. **Combustible**—Capable of bursting into flames at temperatures above 100°F

d. **Flammable**—Capable of being easily ignited and burning quickly at temperatures below 100°F

Note: *Inflammable* means "flammable."

e. **Grounded**—Electrical connection to an object that conducts electrical current to the earth

f. **Guardrail systems**—A barrier erected to prevent employees from falling to lower levels

g. **Hazard**—Potential source of danger

h. **Hazardous material**—Any cancer-causing, corrosive, toxic, irritant, sensitizer, or material that has, or has the potential for, damaging effects on specific body organs

Examples: Bleaches, petroleum products, paints, chlorine and other pool chemicals, cleaning and sanitizing agents, varnishes, paint removers, and carbon monoxide from vehicle exhausts

i. **Heel**—To apply pressure to the bottom of a straight or extension ladder to prevent if from slipping or sliding sideways while in use

j. **Hygiene**—Conditions or practices of cleanliness conducive to health

k. **Lower levels**—Those areas or surfaces to which an employee can fall. Such areas or surfaces include, but are not limited to, ground levels, floors, platforms, ramps, runways, excavations, pits, tanks, material, water, equipment, structures, or any portion of these

l. **Material Safety Data Sheet (MSDS)**—Form that lists and explains each of the hazardous materials that an employee works with so that the employee can safely use the material and respond to emergency situations

m. **Occupational Safety and Health Act (OSHA)**—Federal legislation designed to ensure safe and healthful working conditions for employees

n. **Personal fall arrest system**—A system used to arrest an employee in a fall from a working level. It consists of an anchorage, connectors, a body harness, and may include a lanyard, deceleration device, lifeline, or suitable combinations of these.

o. **Safety**—Freedom from danger, risk, or injury

p. **Safety net**—A net erected under a walking/working level when guardrail systems or personal fall arrest systems are not feasible

q. **Walking/Working level**—Any surface, whether horizontal or vertical, on which an employee walks or works, including, but not limited to, floors, roofs, ramps, bridges, scaffolds, and runways, but not including ladders, vehicles, or trailers, on which employees must be located in order to perform their job duties

Objective 2

General guidelines for dressing safely on the job

a. Wear clothing appropriate for the activity being performed.

b. Wear hard hats and safety shoes on all construction sites.

c. Wear eye protection for the activity being performed.

d. Remove ties and dangling jewelry when working with or near machine tools or rotating equipment.

e. Confine long hair before operating rotating equipment.

f. Remove rings and other jewelry when working in the shop.

g. Wear protective clothing as appropriate.

Examples: Suitable helmets and goggles when welding; eye protection when using electric tools such as saws or drills; face mask when working with invasive fumes; seatbelt at all times when in a moving vehicle

h. Wear dust masks in dusty areas.

i. Wear hearing protection when subjected to continuous loud noise.

j. Wear gloves when handling equipment and materials with sharp edges.

Objective 3

General job and shop safety rules

a. **Awareness and safe conduct**

- Be alert for dangers and hazards.
- Conduct yourself in a safe manner; do not participate in horseplay.
- Do not work overtime in the shop unless the instructor is present.
- Consider the safety of others.
- Do not distract workers operating a tool or machine.
- Work with adequate light.

b. **Hygiene and safety from disease**

- Do not come to work or school sick, and do not continue working if you become sick.
- Use soap and water frequently as a method of preventing and transferring disease.

c. **Fire safety**

- Be familiar with the location of building exits, and fire-fighting and first-aid equipment.
- Be aware of the surroundings before plugging in a power tool or machine.

  Example: Are there any explosives or combustible materials in the area?

d. **Tool use, maintenance, and storage safety**

- Use the right tool or equipment for the job, and use it properly.

  Examples: A stepladder instead of furniture; a screwdriver or scraping tool, not the tip of a kitchen knife
- Keep all tools, sharp, clean, and in safe working order.
- Retain all tool guards and safety devices.
- Operate a hazardous machine only after receiving instruction on how to operate the machine safely in all working conditions.
- Make sure that all guards and barriers are in place and adjusted properly before using a machine or tool.
- Use correct, properly fitting wrenches for nuts, bolts, and objects to be turned or held.
- Keep work areas clean and free of debris and other hazards.
- Store tools, materials, and supplies safely in cabinets, on shelves, or other suitable areas.

  Keep sufficient brooms, brushes, and other housekeeping equipment readily available.
- Clean chips from a machine with a brush, not with a rag or your bare hands.
- Wear eye protection when using grinders and buffers.

e. **Hazardous materials safety**

- Use a solvent only after determining its properties, the kind of work it's intended for, and how to use it.
- Use and store potentially hazardous materials and products strictly according to label instructions and cautions.
- Clean up any spilled liquids immediately.
- Store oily rags or oily waste in self-closing or spring-lid metal containers.

f. **Electrical safety**

- Check all equipment before energizing or activating.
- Disconnect the power from energized tools, and tag or lockout machine tools before performing any maintenance task such as oiling or cleaning.
- Do not run over electrical cords with dollies or carts.
- Do not string electrical cords across traffic lanes.
- Turn off the power before leaving an energized tool or machine.

Objective 4

Hazard communication (HazCom)

a. OSHA established the Hazard Communication Standard (HCS or HazCom) to protect the health and safety of employees.

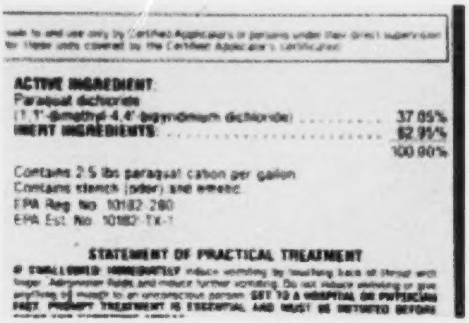
b. This standard states that employees:

- Have the need and a "right to know" the hazards and the identities of the chemicals they are exposed to when working.
- Have the need and a "right to know" what protective measures are available to prevent adverse effects from occurring.

c. OSHA requires employers to develop a written HazCom program including:

- Warning labels on containers

Figure 1



ACTIVE INGREDIENT:
Paraquat dichloride
(1,1'-dimethyl-4,4'-bipyridinium dichloride) 37.05%
INERT INGREDIENTS: 62.95%
100.00%

Contains 2.5 lbs paraquat cation per gallon
Contains stench (odor) and emetic
EPA Reg. No. 10182-280
EPA Est. No. 10182-TX-1

STATEMENT OF PRACTICAL TREATMENT

- Material Safety Data Sheets (MSDS) readily available to employees
- Employee training on the proper handling, usage, storage and transportation of chemicals

Objective 5

Storage of hazardous materials

a. Select an area that meets local, state, and national codes.

b. Store materials in metal cabinets.

Figure 2

c. Keep cabinet or storage area locked.

d. Store in an area away from open flame or excessive heat.

e. Always read labels and follow instructions for proper storage.

Objective 6

Purposes of material safety data sheets (MSDS)

a. To inform the user of the material's physical properties of fast-acting health effects that make it dangerous to handle

b. To tell the user the level of protective gear needed

c. To tell the user the first aid treatment necessary if exposed to the product or its hazards

d. To tell management and the user, the preplanning needed for safely handling spills, fires, and day-to-day operations

e. To tell the user how to respond to accidents

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Objective 7

Colors of the safety color code and their uses

Note: The following colors identify safe and unsafe conditions in the shop. Learn the color code because it could help you prevent accidents to yourself and fellow workers.

a. **Federal safety red**—Basic color for identifying:

- Fire protection equipment and apparatus
- Portable containers of flammable liquids
- Emergency stop bars, stop buttons, and emergency electrical stop switches on machinery

b. **Federal safety yellow**—Basic color for designating:

- Caution and for marking physical hazards
- Waste containers for explosive or combustible materials
- Caution against starting, using, or moving equipment under repair
- Identification of the starting point or power source of machinery

c. **Federal safety orange**—Basic color for designating:

- Dangerous parts of machines
- Safety starter buttons and parts of equipment that may produce electrical shock
- The exposed parts (edges only) of pulleys, gears, rollers, cutting devices, and power jaws

d. **Federal safety purple**—Basic color for designating radiation hazards

e. **Federal safety green**—Basic color for designating:

- Safety
- Location of first aid equipment

  Note: This applies to equipment other than firefighting equipment.

f. **Federal safety black and white**—Basic colors for designating:

- Traffic flow
- Housekeeping zones
- Storage areas

  Note: Black and white colors are used individually or in combination.

g. **Federal safety blue**—Basic color for designating:

- Equipment that should **not** be started, used, or moved

  Examples: Defective equipment, equipment being serviced

  Note: A blue tag is lettered with the words "Out of Order."

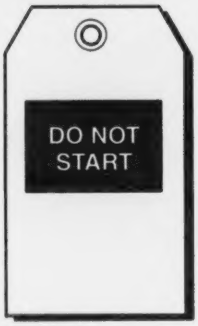
Objective 8

Color coding of safety tags

a. Do not start tag

- White tag
- White letters on red square

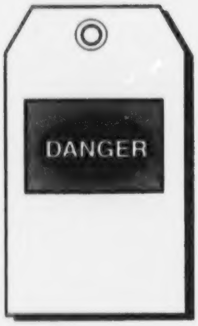
Figure 3



b. Danger tag

- White tag
- White letters in red oval, on black square

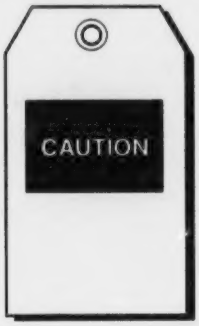
Figure 4



c. Caution tag

- Yellow tag
- Yellow letters on black background

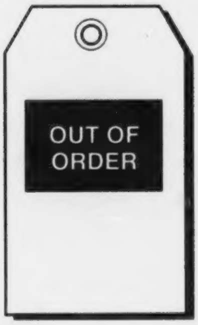
Figure 5



d. Out of order tag

- Blue tag
- White letters on black background

Figure 6



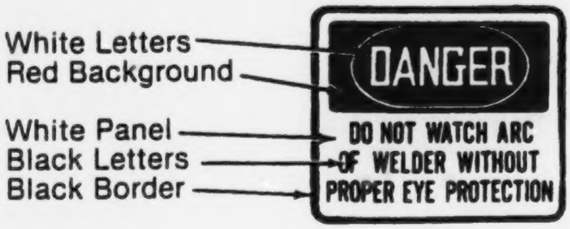
Objective 9

Accident prevention signs, their colors and uses

a. Danger signs

- Used where an immediate hazard exists
- Colors are red, black, and white

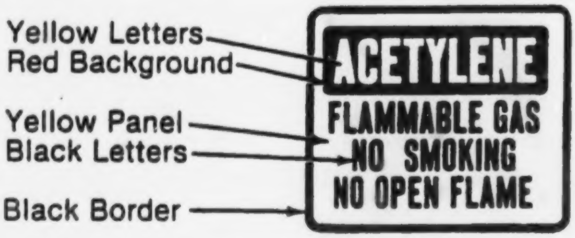
Figure 7


White Letters
Red Background
White Panel
Black Letters
Black Border
DANGER
DO NOT WATCH ARC OF WELDER WITHOUT PROPER EYE PROTECTION

b. Caution signs

- Used to warn against potential hazards or to caution against unsafe practices
- Colors are yellow and black

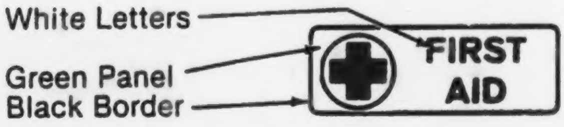
Figure 8


Yellow Letters
Red Background
Yellow Panel
Black Letters
Black Border
ACETYLENE
FLAMMABLE GAS
NO SMOKING
NO OPEN FLAME

c. Safety instruction signs

- Used where there is a need for general instruction and suggestions relative to safety measures
- Colors are white, green, and black

Figure 9


White Letters
Green Panel
Black Border
FIRST AID

Objective 10

Components of the fire triangle

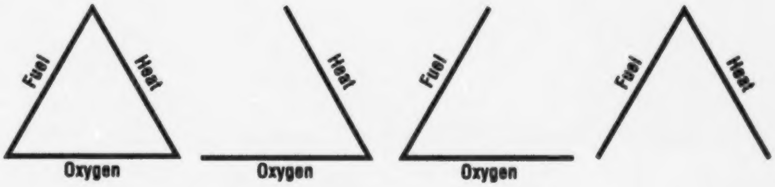
a. Fuel—Any combustible material

b. Heat—Enough to raise the fuel to its ignition temperature

c. Oxygen—Necessary to sustain combustion

Note: To produce fire, the three elements of the fire triangle must be present at the same time. If any one of the three is missing, a fire cannot be started. With the removal of any one element, the fire will be extinguished.

Figure 10



Objective 11

Types of fires and their classifications

a. **Class A**—Fires that occur in ordinary combustible materials

Examples: Wood, rags, paper, or trash

b. **Class B**—Fires that occur in flammable liquids

Examples: Gasoline, oil, grease, paints, or thinners

c. **Class C**—Fires that occur in electrical and electronic equipment

Examples: Motors, switchboards, circuit wiring, radios, or television sets

d. **Class D**—Fires that occur in combustible metals

Examples: Powdered aluminum or magnesium

Objective 12

General types of fire extinguishers and their uses

a. **Foam**—Instead of spraying stream into the burning liquid, allow foam to fall lightly on the fire; use for Class A or Class B fires.

b. **Carbon dioxide**—Direct discharge as close to fire as possible, first at the base of flames, then gradually forward and upward; use for Class B or Class C fires.

c. **Dry powder**—Direct at base of flames; use for Class D fires.

d. **Dry chemical**—Direct at base of flames; follow up by directing the dry chemicals at remaining materials that are burning; use for Class B or Class C fires.

e. **Halon**—Direct at base of flames, sweeping from side to side; use for Class C fires.

Note: Halon is a clean, liquid gas that does not leave a residue.

> **Caution:** A high concentration halon gas may be hazardous to your health because it displaces oxygen in air.

Objective 13

Fire extinguisher markings

Figure 11

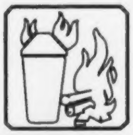
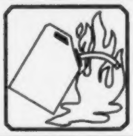
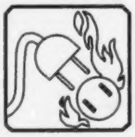
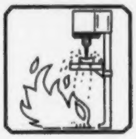
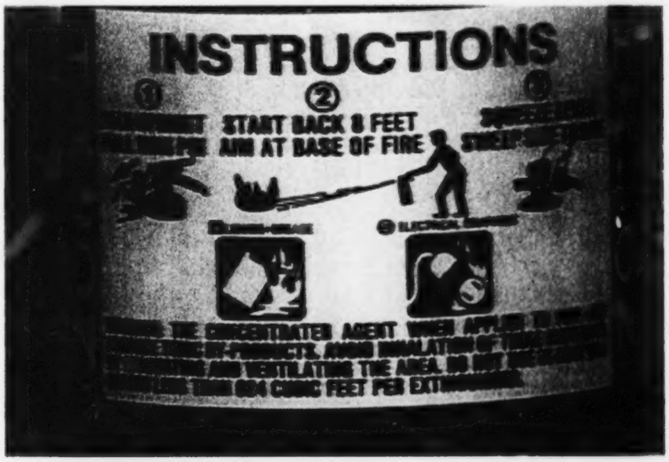
Class of Fire	Graphic Symbol (Color and shape)	Pictorial Symbol
Class A	A (Green Triangle)	
Class B	B (Red Square)	
Class C	C (Blue Circle)	
Class D	D (Yellow Star)	

Figure 12

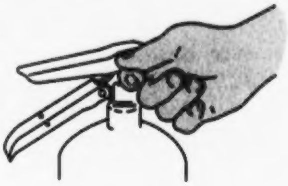

INSTRUCTIONS
②
START BACK 8 FEET
AIM AT BASE OF FIRE

Objective 14

Fire extinguisher general operating instructions that follow the letters P-A-S-S

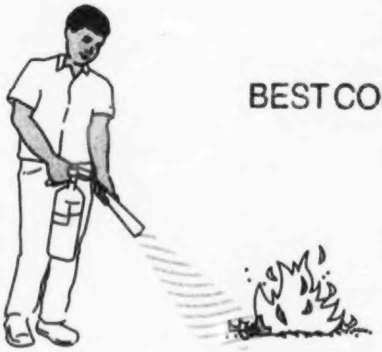
a. **P**–ull the pin at the top of the extinguisher that prevents the handle from being pressed.

Figure 13



b. **A**–im the nozzle toward the fire.

Figure 14



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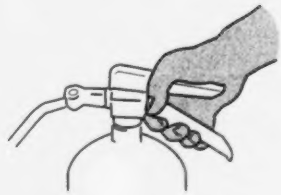
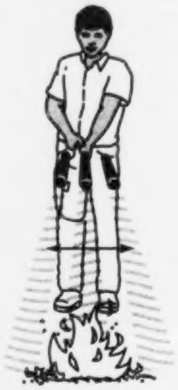
c. **S**–queeze the handle to discharge the extinguishing agent.

Figure 15



d. **S**–weep the nozzle back and forth at the base of the flames to disperse the extinguishing agent.

Figure 16



Objective 15

Contributing factors and causes of back injuries

a. **Weight**—Injury results from overestimating your physical abilities and trying to lift more weight than you can handle.

b. **Size**—Injury usually results from moving an object that may be within your weight capacity, but is too long, high, or wide to lift safely.

c. **Shape**—Injury usually results from moving an object that may be within your weight capacity, but has a cylindrical shape or other odd shape that makes safe lifting difficult.

d. **Obstructions**—Injury usually results from stacking materials so high that vision is limited and obstructions in the pathway cannot be seen.

e. **Improper position**—Injury usually results from twisting or turning to an awkward position when lifting.

f. **Improper storage**—Injury usually results in strain caused by not storing heavy objects at least 12 inches off the floor.

g. **Improper reaching**—Injury usually results from carelessly using chairs or boxes instead of safely using a ladder, or by positioning/elevating an object too far from work.

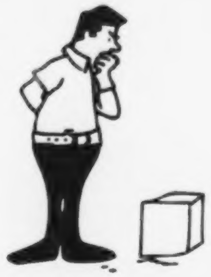
Objective 16

Guidelines for lifting and moving items safely

a. Before lifting

- Inspect the item to be lifted for jagged edges, splinters, and grease or other slippery surfaces.

Figure 17



- Wear gloves for protection, and make sure that they fit properly.
- Wear lower-back support.

  Example: Leather lower-back support belt

- Plan your route before you lift.
- Clear any obstacles from your path.
- Assess the weight of the load.
- Get help to lift heavy loads.

  Note: Teamwork works best when both persons are about the same size. The load should be distributed evenly between both workers.

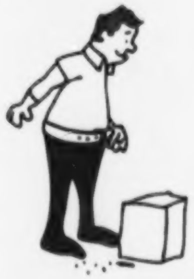
- Use a dolly to move very heavy, large, or awkward loads that cannot (or should not) be lifted by two people.

  Examples: Piano, refrigerator, sofa bed

b. Lifting

- Place your feet as close to the load as possible, one foot alongside the load and the other behind it.

Figure 18



- Bend your knees, keeping your back and neck straight and your chin tucked in.
- Grasp the load firmly with your fingers and hands.
- Draw your arms in close to your body.
- Stand slowly and lift smoothly, using your legs.

Figure 19

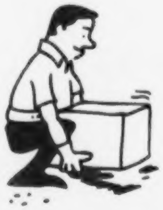
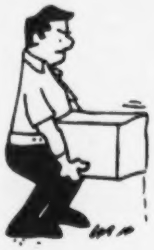


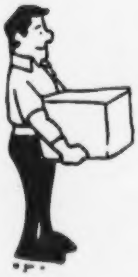
Figure 20



c. **Carrying**

- Hold items close to your body.

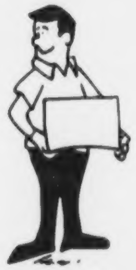
Figure 21



341

- Do not allow load to block your vision.
- Do not change your grip or twist your body to change direction.

Figure 22

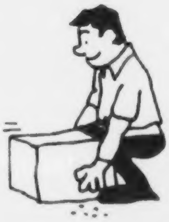


Note: Twisting the back while carrying a load (even a small one) can result in severe back injury.

d. **Setting down the load**

- Bend your knees.
- Keep your back and neck straight and aligned.
- Place load carefully where you want it, taking care not to allow it to rest on your feet or fingers.

Figure 23



Objective 17

Guidelines for preventing slips, trips, and falls

a. Wipe up spills immediately.

b. Post warning signs when floors are wet.

c. Use handrails on stairs.

d. Report any tripping hazard.

Examples: Loose boards, loose tiles, broken steps, torn or curled carpets

e. Do not leave equipment, materials, or other obstacles in hallways, on stairs or landings, before doors and exits, or in any other area where people may trip over them.

f. Do not stretch extension cords across traffic areas.

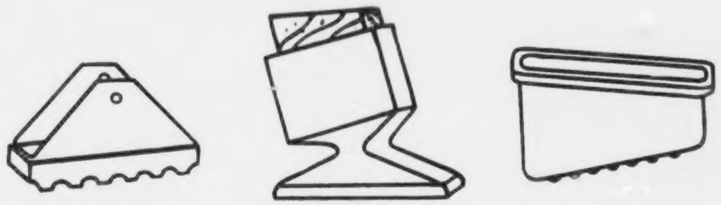
g. Use a ladder instead of a chair or box to reach high objects or areas.

Objective 18

Rules for using ladders safely

a. Make sure the ladder has non-skid safety shoes.

Figure 24



b. Inspect the ladder before use for worn safety shoes, broken or loose rungs/steps, or other defects.

c. Inspect the ladder rungs/steps and siderails for oil or other slippery materials before you climb.

d. Never use metal ladders for electrical work.

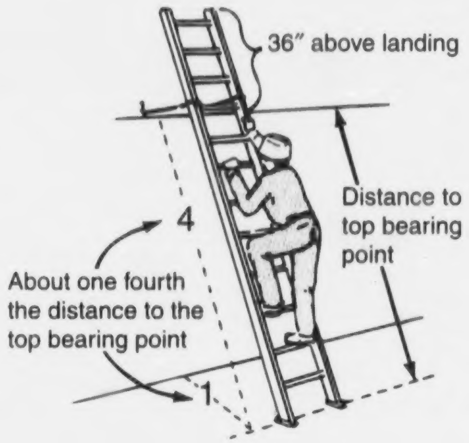
e. Locate the ladder away from doors or other openings that are not blocked or guarded.

f. Place ladder feet on a level, non-skid surface.

g. Place ladder at a safe angle to the work: at least 1 foot from the wall for every 4 feet of height.

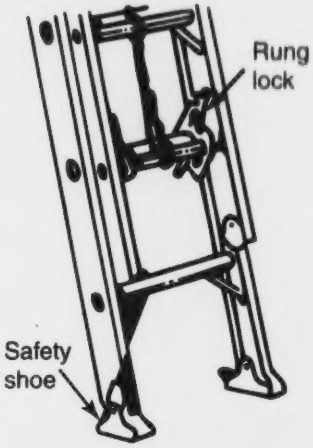
Note: Get help in carrying and raising heavy or long ladders.

Figure 25


36" above landing
Distance to top bearing point
4
About one fourth the distance to the top bearing point
1

h. Use rung locks to secure the sections of extension ladders.

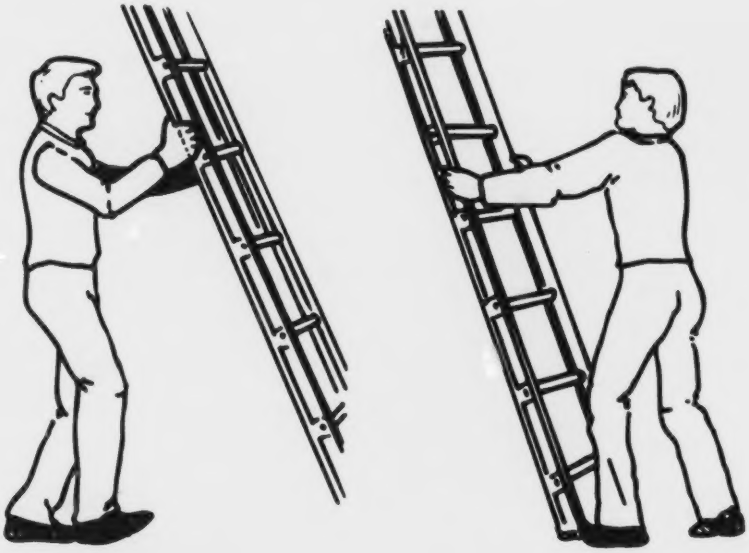
Figure 26



i. Place top of extension and straight ladders at least three rungs above the work.

j. Get a helper to heel straight or extension ladders.

Figure 27



k. Face the ladder when climbing up and down.

l. Never stand on the top rung/step.

m. Do not overextend your reach while on the ladder; descend the ladder and reposition it instead.

n. Allow only one person on the ladder at a time.

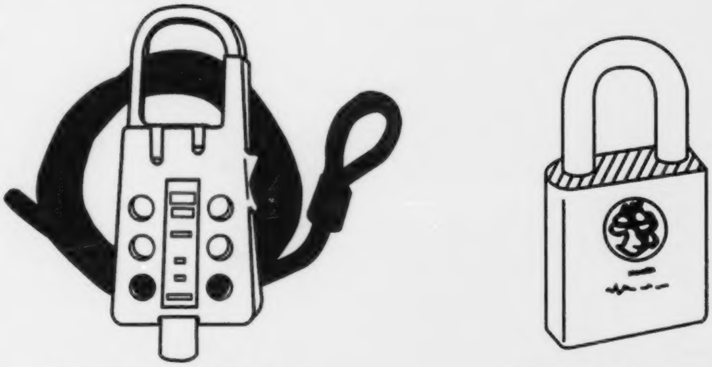
o. Do not use ladders for makeshift scaffolds.

p. Store ladders securely when not in use.

Objective 19

When to use lockout devices

Examples: Figure 28



Group Lockout Device

Single Lockout Device

a. Use when more than one power source is present.

b. Always use when hydraulic position could change.

c. Always use when pneumatic position could change.

d. Use to lock off all electrical devices before working on equipment.

Objective 20

Fall Protection Systems

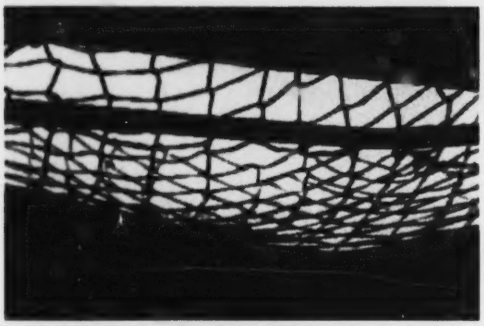
Each employee on a walking/working surface with an unprotected edge which is 6 feet or more above a lower level, shall be protected from falling by the use of one of the following three methods:

a. Guardrail systems

Figure 29

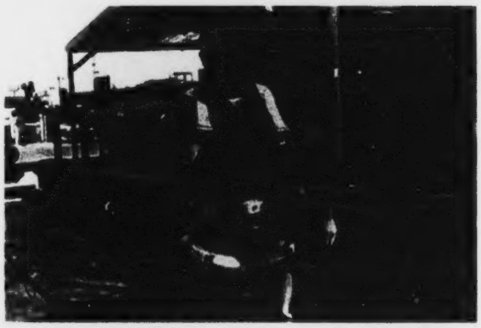
b. Safety nets

Figure 30



c. Personal fall arrest systems

Figure 31



Objective 21

Confined space entry

a. **Confined space**—Any space that has the following characteristics:

- Large enough or so configured that an employee can bodily enter and perform assigned work
- Has limited or restricted means for entry or exit. Confined-space openings are limited primarily by size and location. Openings may be small in size and may be difficult to move through easily. Entrance and exit may be required from top, bottom, or side. Size or location may make rescue efforts difficult.
- Is not designed for continuous employee occupancy

b. **Non-permit confined space**—A confined space that does not contain or, with respect to atmospheric hazards, have the potential to contain any hazard capable of causing death or serious physical harm.

c. **Permit-required confined space**—A confined space that has one or more of the following characteristics:

- Contains or has potential to contain a hazardous (toxic or oxygen deficient) atmosphere

- Contains a material that has the potential for engulfing an entrant (flammable atmosphere)
- Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor that slopes downward and tapers to a smaller cross-section (mechanical or physical hazard)
- Contains any other recognized serious safety or health hazard

d. **Permit-required confined space program**—The employer's overall program for controlling, and where appropriate, for protecting employees from, permit space hazards and for regulating employee entry into permit spaces.

Note: Where a welder must enter a confined space through a manhole or other small opening, means shall be provided for quickly removing him in case of emergency. When safety belts and lifelines are used for this purpose, they shall be so attached to the welder's body that his body cannot be jammed in a small exit opening.

Figure 32

Objective 22

Respirator requirements

a. Respirators shall be used anytime the work environment is contaminated with:

- Harmful dusts
- Fogs
- Fumes
- Mists
- Gases
- Smokes
- Sprays
- Vapors

Student Supplement 1—Guidelines for Interpreting Material Safety Data Sheets

This supplement was prepared in conjunction with Assignment Sheet 2, and should be read and understood prior to attempting that assignment.

Living in the modern world, you probably are aware that the use of chemicals offers convenience and progress at home and work. Naturally, you want to avoid dangerous overexposure to chemicals, especially on the job. Such overexposure is possible no matter where you work, even in an office or light industry.

Your company's hazard communications, or HazCom, program was created to protect your health and safety. Three important elements are at the heart of your HazCom program: warning labels on containers, training on the safe use and handling of chemicals, and material safety data sheets (MSDSs).

What is on an MSDS

MSDSs are printed pages that give you all the critical information you need about how to use, transport, and store chemicals in order to protect yourself, as well as what to do in case of emergencies and overexposure. Information on MSDSs includes:

- The chemical's name or names
- Name, address, and phone number of the manufacturer
- List of the chemical's ingredients
- Permissible exposure limits (PEL) or threshold limit value (TLV)
- What conditions or other substances will cause the chemical to catch fire, explode, melt, or turn into dangerous gases
- How the chemical usually looks and smells
- How to put out a fire involving the chemical
- What to do if the chemical spills or leaks
- How to prevent dangerous exposure
- Health hazards such as skin irritant or cancer-causing agent
- Symptoms of overexposure
- What to do if you are overexposed
- When the MSDS was prepared

The information for each chemical's MSDS is put together by the manufacturer or distributor for that chemical. The sheets often look different from each other, but they still provide the same information. The law requires your employer to keep MSDSs up to date and to send the MSDS to your doctor or designated representative if you request it.

Where the MSDS is kept

MSDSs must be readily accessible to employees—a posted sign may tell you where, and you can also find out by reading your company's written HazCom program. If you are not sure where to find MSDSs, your supervisor or your company's HazCom contact will make them available to you. It is the law.

When to read an MSDS

You should always read the MSDS before you begin a job using a chemical. Even if you have used the chemical before, the manufacturer may have changed its formula, which may change the steps you should take to protect yourself. Taking proper precautions listed on the MSDS, such as wearing a respirator, can prevent serious long-term illnesses.

If you do not understand something on the MSDS, or have questions about your company's HazCom program, ask your supervisor or company contact. Your company knows that HazCom works best if you are fully informed and involved.

How to read an MSDS

The material safety data sheet, or MSDS, is written information that can help protect you from overexposure to chemicals you find on the job. The MSDS is part of your company's hazard communications program. Each company can design its own MSDS form, and the sections may be in a different order. But the basic kinds of information on any MSDS will be the same.

Chemical name (see Figure 1). Lists the identity of the substance (the name on the label, date the MSDS was prepared, the name and address of the manufacturer, and usually a phone number for emergencies and more information).

Hazardous ingredients/chemical identity (see Figure 1). Includes names of substances in the chemical that might be dangerous, and lists safety exposure limits such as permissible exposure limit or PEL (set by OSHA) or the threshold limit value or TLV. Also lists common names for the chemical.

Physical characteristics (see Figure 1). Describes many physical qualities of the chemical, and lets you know what is usual or safe. For example, how the chemical looks and smells; boiling and melting temperatures (important in case a chemical might become a gas you could breathe); evaporation rate (known as percent volatile); how easily the chemical dissolves; and how heavy it is (this tells you if it will sink, float, or dissolve in water).

Student Supplement 1

Figure 1

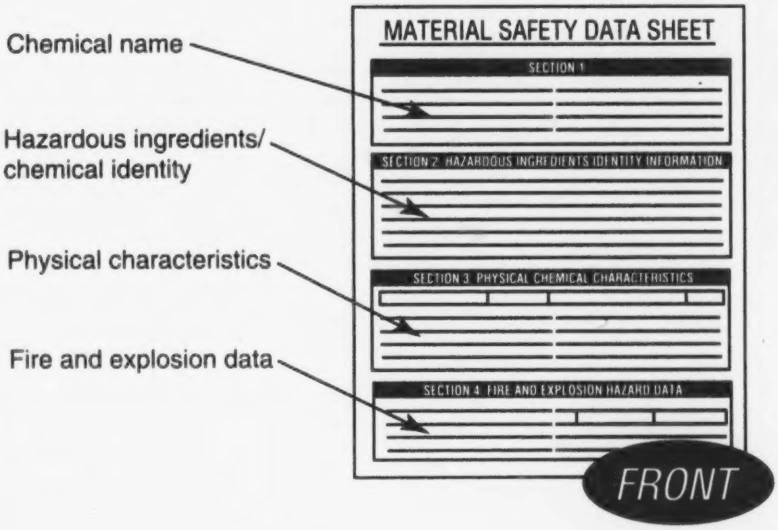
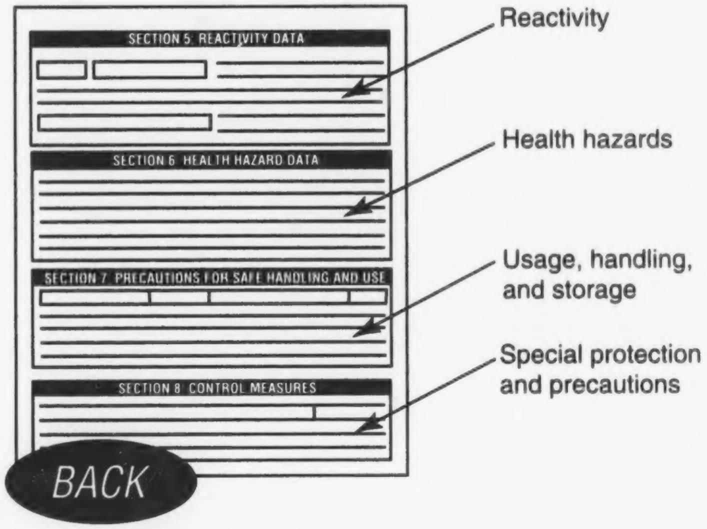

Chemical name
Hazardous ingredients/ chemical identity
Physical characteristics
Fire and explosion data
MATERIAL SAFETY DATA SHEET
SECTION 1
SECTION 2 HAZARDOUS INGREDIENTS IDENTITY INFORMATION
SECTION 3 PHYSICAL CHEMICAL CHARACTERISTICS
SECTION 4 FIRE AND EXPLOSION HAZARD DATA
FRONT

Figure 2


SECTION 5 REACTIVITY DATA
SECTION 6 HEALTH HAZARD DATA
SECTION 7 PRECAUTIONS FOR SAFE HANDLING AND USE
SECTION 8 CONTROL MEASURES
BACK
Reactivity
Health hazards
Usage, handling, and storage
Special protection and precautions

Fire and explosion data (see Figure 1). Tells you the lowest temperature at which the chemical could catch fire (flash point). Lets you know if it is flammable (catches fire below 100°F) or combustible (catches fire above 100°F). Lists the best way to put out a fire involving that chemical.

Reactivity (see Figure 2). Describes what happens if this chemical comes in contact with air, water, or other chemicals. Describes conditions (like heat) or materials (like water) that can cause the chemical to react by burning, exploding, or releasing dangerous vapors. The chemical is called "incompatible" or "unstable" with these conditions or substances.

Health hazards (see Figure 2). Lists ways the chemical might enter your body, like splashing on your skin or being breathed in as vapor, as well as possible symptoms of overexposure. Lets you know if overexposure might make existing medical conditions worse, and describes emergency first aid procedures.

Usage, handling, and storage (see Figure 2). Describes how to clean up an accidental spill, leak, or release, including special procedures. Tells you how to handle, store, and dispose of chemicals safely. Remember, if there is an accident, notify your supervisor immediately. Take care of it yourself only if you are trained to do so and are wearing the proper equipment.

Special protection and precautions (see Figure 2). Explains special personal protective equipment (PPE) and other equipment to use when working with the chemical, special procedures, extra health or safety information, signs that should be posted, and other information not covered in other sections.

Terms and abbreviations used on MSDSs

The following terms and abbreviations will help you interpret material safety data sheets.

- **TLV**—Threshold limit value; a time-weighted average concentration under which most people can work consistently for 8 hours a day, day after day with no harmful effects
- **Ceiling**—Uppermost limit
- **ACGIH**—American Conference of Governmental Industrial Hygienists
- **OSHA**—Occupational Safety and Health Administration
- **PEL**—Permissible exposure limit; the maximum time-weighted concentration *at which* 95 percent of exposed, healthy adults suffer no adverse effects over a 40-hour week
- **ppm**—Parts per million
- **STEL**—Short-time exposure limit; a 15-minute, time-weighted average that should not be exceeded at any time during a workday. Exposures at STEL should not be longer than 15 minutes and should not be repeated more than four times a day with at least 60 minutes between exposures.

- **IDLH**—Immediately dangerous to life and health; material *at* or *above* this level poses an immediate hazard to life or produces immediate, irreversible, debilitating effects
- **LEL**—Lower explosive limit; below the flammability range (too lean to burn)
- **UEL**—Upper explosive limit; above the flammability range (too rich to burn)

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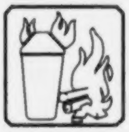
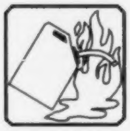
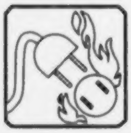
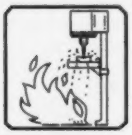
Student Supplement 2—Using Portable Fire Extinguishers

This supplement was prepared in conjunction with Assignment Sheet 4, and should be read and understood prior to attempting that assignment.

All portable fire extinguishers are labeled with picture and shape symbols. Each of the shape symbols (triangle, square, circle, and star) contains the letter of the fire class for which the extinguisher is effective. The picture symbols not only illustrate what type(s) of fire the extinguisher may be used on, but also tell what class(es) of fire the extinguisher should **not** be used on. All this information, as well as directions for using the extinguisher, are printed on the extinguisher. However, when a fire is discovered, speed is important, and, as the saying goes, "a picture is worth a thousand words." You should be able to glance at the symbols on an extinguisher and know immediately whether the extinguisher is appropriate for the fire on hand.

Below are examples of fire-class shape symbols and their meanings, and examples of extinguisher picture symbols and their meanings.

(Green) ▲ A	**Class A** • Ordinary combustibles 	(Red) ■ B	**Class B** • Flammable liquids and gases 
(Blue) ● C	**Class C** • Live electrical equipment 	(Yellow) ★ D	**Class D** • Combustible metals 

Unit Contents

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Student Supplements

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2—A Systematic Look at First Aid 3–33

*Assignment Sheet

1—Determine Basic First Aid Measures for Given Emergency Situations 25

*The Assignment Sheet is located in the Student Workbook.

Prerequisites:
None

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

Optional ☐ 3. **Research** Online resources regarding safety and health issues in welding. Visit www.osha.gov as one of your resources.

Optional ☐ 4. **View** Videotape entitled: "Health and Safety Factors in Welding."

☐ 5. **Study** Information Sheet, Objective 1.

Optional ☐ 6. **View** Videotape entitled: "Health Factors in Welding Operations."

☐ 7. **Study** Information Sheet Objectives 2 through 5.

Optional ☐ 8. **View** Videotape entitled: "Eye Protection–A New Approach."

☐ 9. **Study** Information Sheet, Objectives 6 and 7.

☐ 10. **Read** Student Supplement 1, "Lens Shade Selection Charts."

☐ 11. **Study** Information Sheet, Objectives 8 through 14.

Optional ☐ 12. **View** Videotape entitled: "Safe Handling of Compressed Gas Cylinders."

☐ 13. **Study** Information Sheet, Objective 15.

Optional ☐ 14. **View** Videotape entitled: "Safe Use of Compressed Gas Cylinders."

Learning Activities Sheet

Optional

☐ 15. **Research** Online resources regarding safety in storing and handling compressed gases. Visit www.cganet.com as one of your resources.

☐ 16. **Study** Information Sheet, Objectives 16 through 18.

Optional

☐ 17. **View** Video entitled: "Bloodborne Pathogens in the Workplace."

Optional

☐ 18. **Research** Online resources regarding workplace safety. Visit www.redcross.org as one of your resources.

Optional

☐ 19. **View** Videotape entitled: "Heat Stress."

☐ 20. **Study** Information Sheet, Objective 19.

☐ 21. **Read** Student Supplement 2, "A Systematic Look at First Aid."

☐ 22. **Do** Assignment Sheet 1, "Determine Basic First Aid Measurers for Given Emergency Situations."

☐ 23. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 24. If the evaluation is not satisfactory, repeat Steps 20 through 22.

☐ 24. **Check** With instructor for any additional assignments to be completed.

☐ 25. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 26. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Objective Sheet

Unit Objective

After completing this unit, the student should be able to practice basic welding safety and perform basic first aid. The student should demonstrate these competencies by completing the assignment sheet and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to welding safety and first aid with their definitions.
2. Complete statements about the ALWAYS rules for welding safety.
3. Complete statements about the NEVER rules for welding safety.
4. Solve problems about protective clothing required for welding.
5. Select true statements about wearing proper eye protection.
6. Select solutions for hazards from arc rays.
7. Differentiate between types of welding hoods.
8. Solve problems concerning guidelines for duty cycle safety.
9. Select true statements about important rules for handling welding cables and gas and coolant hoses.
10. Complete statements about guidelines for oxygen safety.
11. Select true statements about guidelines for acetylene safety.
12. Select true statements about guidelines for other fuel gas safety.
13. Complete statements about guidelines for shielding gas safety.
14. Complete statements about rules for storing compressed gas cylinders.
15. Complete statements about rules for moving compressed gas cylinders.
16. List the general steps for handling any emergency situation.
17. Complete statements concerning general guidelines for first aid emergencies.
18. Describe basic first-aid procedures for various emergency situations.
19. Select facts about treating a victim of electrical shock.

*20. Determine basic first aid measures for given emergency situations. (Assignment Sheet 1)

*The Assignment Sheet is located in the Student Workbook.

Information Sheet

Objective 1

Terms and definitions

a. **Acquired Immune Deficiency Syndrome (AIDS)**—Life-threatening bloodborne virus that depresses the cells of the immune system

Note: It is important to protect yourself against AIDS infection when administering first aid to a victim. See information sheet objective 18.

b. **Anaphylactic shock**—Severe and sometimes fatal reaction to an antigen (as bee venom); characterized by respiratory symptoms, fainting, and itching

c. **Arc burn (Flash burn)**—A burn on the exterior membrane of the eye caused by exposing the naked eye to the ultra-violet and infrared rays in the flash of an electric arc, or the exposure of improperly covered body areas to the flash of an electric arc

d. **Cardiopulmonary resuscitation (CPR)**—Procedure for restoring normal breathing after cardiac arrest

e. **Electrical shock**—The sudden stimulation of nerves and muscles caused by the discharge of electricity through the body when the body contacts an energized electrical circuit

Note: Electrical shock can cause serious burns, muscle damage, and death. Human body resistance varies from about 500,000 ohms when dry to about 300 ohms when wet. Because of this, voltages as low as 30 volts can cause enough current to be fatal. Any circuit with a potential of at least 30 volts must be considered dangerous.

f. **First aid**—Immediate temporary care given the victim of an accident or sudden illness until the services of a physician can be obtained

g. **First-degree burn**—Burn affecting only the outer skin layers; characterized by redness and pain

h. **Hepatitis**—Infectious disease marked by inflammation of the liver

Note: It is important to protect yourself against hepatitis infection when administering first aid to a victim. See information sheet objective 18.

i. **Occupational Safety and Health Act (OSHA)**—Federal legislation designed to ensure safe and healthful working conditions for employees

j. **Safety**—Freedom from danger, risk, or injury

k. **Second-degree burn**—Burn penetrating beneath the superficial skin layers; characterized by swelling and blisters

l. **Third-degree burn**—Burn that destroys all skin layers and underlying tissue; characterized by white, leathery appearance and lack of pain

Note: Third-degree burns are not painful because nerve tissue has been destroyed.

Information Sheet

Objective 2

The ALWAYS rules for welding safety

a. Always wear suitable protective clothing and eye protection.

b. Always keep a safe, clean work area.

c. Always keep welding equipment in good condition.

d. Always check welding areas to make sure they're safe to work in.

e. Always respect gas cylinders as dangerous and potentially lethal.

f. Always remove any combustibles, such as a lighter or matches from your person before doing any welding or cutting.

g. Always make sure ventilation provides three to four complete changes of air per hour.

h. Always look out for fellow students and coworkers.

Objective 3

The NEVER rules for welding safety

a. Never enter the welding shop without wearing safety glasses.

b. Never weld, cut, or grind near flammable or explosive materials.

c. Never use oil on gas cylinders, regulators, connections, or hoses.

d. Never permit an electrode holder to come in contact with a welding machine or a gas cylinder.

e. Never operate ungrounded equipment.

f. Never cut or weld directly on concrete.

g. Never arc weld or operate electrically powered equipment while standing on wet or damp floors.

h. Never cut into barrels, drums, or any container that has not been purged or filled with water.

Note: Before heat is applied to a drum, container, or hollow structure, a vent opening shall be provided for the release of any built-up pressure during the application of heat.

i. Never engage in horseplay of any kind.

j. Never ground electrical equipment to an attached building member or a piece of equipment or to part of a building.

Objective 4

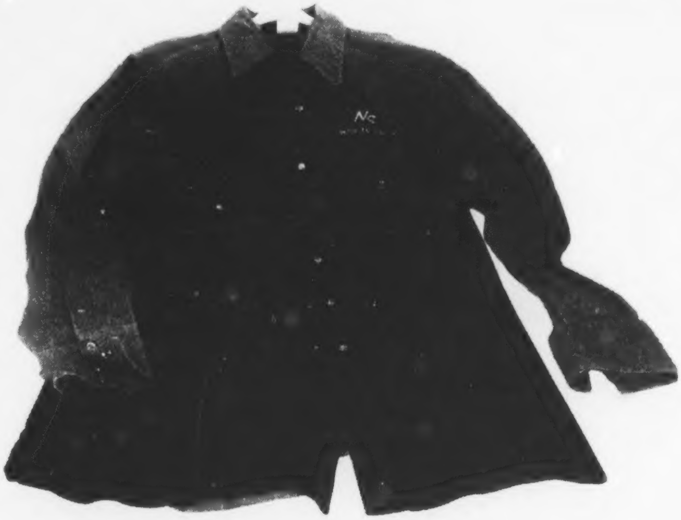
Personal protective clothing

Caution: Always avoid clothing with tears, snags, rips, or worn spots. They are easily ignited by sparks.

a. Shirts

- Should be heavy long sleeve shirts with pocket flaps
- Keep collar and sleeves buttoned to keep out sparks, and remove pockets from front of shirt or tape them shut if they don't have pocket flaps

Figure 1



b. Pants

- Should have no cuffs and be long enough to come down over shoe/boot tops

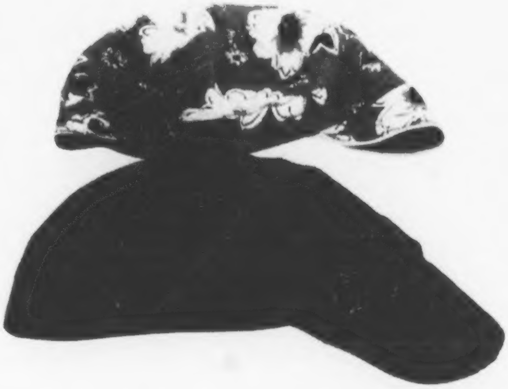
Caution: Clothes made of polyester and other synthetics catch fire easily so it's better to wear wool or heavily-starched cottons.

c. Welding Cap

- Should be worn to protect hair from sparks and spatter
- Has a flexible bill that can be slipped around to cover either ear and keep sparks or metal splatter out of the ear opening

Caution: Some hair sprays are highly flammable and can be ignited by sparks, and any kind of plastic hair cap or covering is dangerous in the welding area.

Figure 2



d. Boots

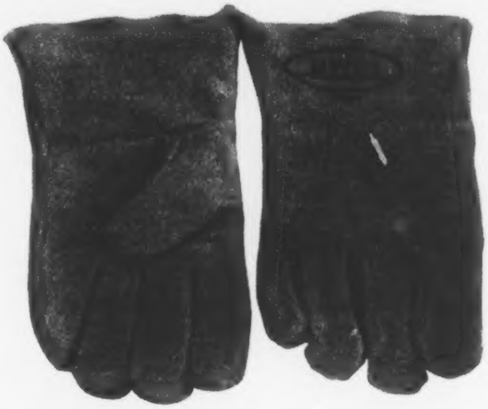
- Should be made of heavy leather with uppers that reach above the ankle to help prevent burns from sparks and spatter
- Boots should be steel toed, and steel-toed boots are required in many states
- If low topped shoes are worn, the ankles should be protected by fire resistant leggings

Note: Never wear sneakers, tennis shoes, sandals, or loafer-type shoes when welding.

e. Gloves

- Heavy leather gloves with gauntlets are required for all welding and cutting activities. Gauntlets may be short or extend to the shoulder.

Figure 3

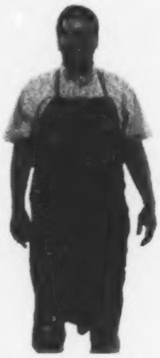


f. Jackets and Aprons

- Leather jackets and aprons should be worn for additional protection, especially when welding out of position or in confined areas where flying sparks present an increased hazard.

Figure 4

Figure 5



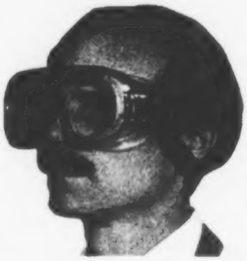
Objective 5

Eye protection

a. Wear safety glasses at all times in the welding shop.

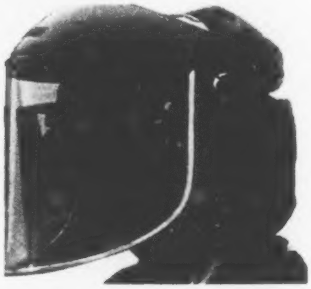
Note: Use eye protection that provides side protection when there is a hazard from flying objects. Detachable side protectors (e.g. clip-on or slide-on side shields) are acceptable.

Figure 6



b. Wear safety glasses and a face shield when grinding, chipping, cutting, or shaping metal with any kind of power tool.

Figure 7



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c. If you wear contact lenses, check with your doctor to see if the type of lens you wear requires any special precautions in the work environment.

Note: Reports that an electric arc can burn a contact lens to the cornea of the eye are false, but dust or other contaminants in the air can be irritating to persons who wear contact lenses, and some work environments may merit special precautions for contact lens wearers.

d. If prescription lenses are required while engaged in operations that involve eye hazards, wear eye protection that incorporates the prescription in its design.

Note: Eye protection that can be worn over the prescription lenses without disturbing the proper position of the prescription lenses or the protective lenses may also be used.

e. Do not wear plastic-coated lenses for welding or cutting.

f. Wear welding goggles or a welding hood with the proper lens shade for all welding and cutting activities.

g. Select proper lens shade for the welding or cutting activity, and make sure the lens is not chipped, cracked, or damaged.

h. Remember that lens shade numbers are not additive. In other words, a #8 and a #6 lens will not give the same density as a #14 lens, so don't mix lenses.

Objective 6

Hazards from arc rays

a. A welding arc produces ultraviolet and infrared radiation that can severely burn eyes that are unprotected with a proper shade of protective lens.

Note: Wear safety glasses with UV protective side shields in addition to a proper welding helmet with filter plate. The side shields provide needed protection from reflected radiation.

b. Radiation from a welding arc is strong enough to burn or sometimes blister bare skin if the exposure is intense or for an extended period, so arms, legs, and torso should be covered with durable flame-resistant clothing.

c. Work stations and work areas should be shielded to prevent an arc flash from injuring nearby workers or visitors.

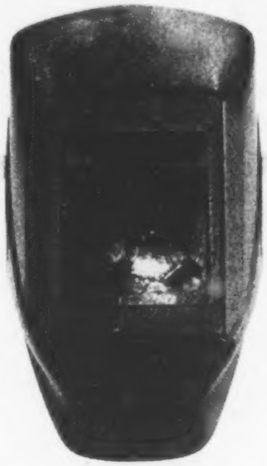
Objective 7

Types of welding hoods

a. Stationary filter lens—This type hood has a fixed lens housing with the shaded lens held in by a spring retainer from where a lens can be slipped out and replaced as welding requires.

Note: Always check the clear face lens to make sure it's clean and free of scratches.

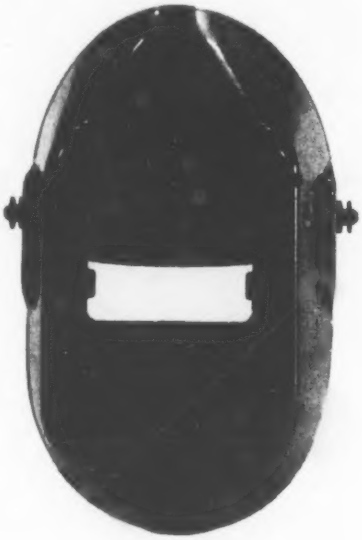
Figure 8



b. Flip-front filter lens—This type hood has a lens housing with a front side that can be flipped up so that it leaves a clear-glass lens that permits the hood to be worn while chipping.

Note: Always check the clear face lens to make sure it's clean and free of scratches.

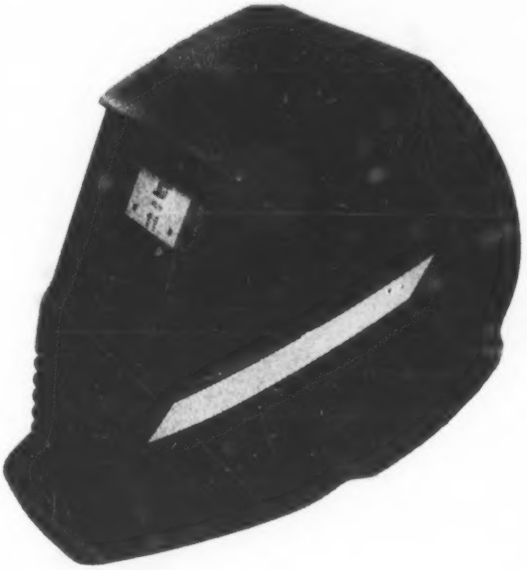
Figure 9



c. Auto darkening lens

- Used with a helmet specifically designed for auto darkening lenses
- Contains sensors that automatically change the shade from clear to dark in a fraction of a second when you start to weld
- Gradually changes from dark to clear when you stop welding
- Can be manually adjusted to a variety of shades

Figure 10



Objective 8

Guidelines for duty cycle safety

a. Duty cycle is the percent of time a power source can be operated before it overheats.

b. Duty cycle is based on a ten minute period and the length of time during that period that a machine can be safely operated.

c. A machine with a 20 percent duty cycle could safely operate 2 minutes out of each 10 minute period.

d. Since duty cycle is rated at the maximum output of a welding machine at a given amperage setting, the lower the percentage, the more attention is required to time spent actually welding.

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Objective 9

Important rules for handling welding cables and gas and coolant hoses

a. Never drag cables or hoses through dirt or oil, and never pull on a cable to force it over an obstruction.

b. Use only clean, dry rags to clean cables and hoses.

> **Caution:** Never use gasoline or an oily rag on cables and hoses

c. When not in use, keep cables and hoses coiled free of kinks and properly stored.

d. Never drape a welding cable over any type of gas cylinder, and NEVER strike an arc on a gas cylinder.

e. Never interchange gas and water hoses.

f. Disconnect and remove electrode holders and cables used.

g. Keep cables off metal tables or any grounding surfaces.

h. Make sure water-cooled systems have water turned off when shutting down.

i. Use welding cable covers.

Objective 10

Guidelines for oxygen safety

a. Since oxygen under pressure may react violently in the presence of oil or grease, all oxygen fittings and equipment should be kept free of oil and grease.

> **Caution:** Do not use detergent solutions to test for leaks around oxygen cylinders. Many detergents contain oil.

b. Oxygen cylinders should never be stored near highly combustible materials such as acetylene cylinders.

c. Oxygen should be used and stored with the valve end up.

d. Refrigerated oxygen cylinders have a double wall construction to help maintain a vacuum, and such cylinders should be handled with extreme care.

e. Avoid skin contact with liquid oxygen because its extremely low temperature can cause frostbite.

f. Oxygen cylinders should be protected against excessive temperature rises.

Objective 11

Guidelines for acetylene safety

a. Because acetylene burns readily, acetylene cylinders should be kept safely away from open flames.

b. Acetylene cylinders should be stored in clean, dry, well ventilated locations free from other combustibles.

c. Never withdraw acetylene from a cylinder at pressure over 15 psi.

d. Never use acetylene from a cylinder that is lying on its side because acetone withdrawn with the acetylene could damage equipment and cause inferior welds.

e. Acetylene cylinders should be protected against excessive temperature rises.

Objective 12

Guidelines for other fuel gas safety

a. Propane and MPS (methylacetylene-propadiene stabilized) cylinders should be stored in clean, dry, well ventilated locations free from other combustibles.

b. Both propane and MPS cylinders should be used and stored in an upright position.

c. Natural gas in cylinders should be handled with the same precaution as other fuel gas cylinders.

d. Whether used from a cylinder or from a piped-in supply, natural gas should be used with torches and tips designed for use with natural gas.

Objective 13

Guidelines for shielding gas safety

a. In all cases, shielding gases should be used and stored in an upright position.

b. Avoid skin exposure to carbon dioxide and nitrogen because both gases are cold enough to cause frostbite.

c. Because they can displace oxygen in the air, some nonflammable shielding gases such as argon, nitrogen, carbon dioxide, and helium should be stored in well ventilated areas.

Objective 14

Rules for storing compressed gas cylinders

a. Store cylinders on fireproof flooring only.

b. While stored, valve protection caps shall be in place and secured.

c. Compressed gas cylinders shall be secured in an upright position at all times.

d. A suitable cylinder truck, chain, or other steadying device shall be used to keep cylinders from being knocked over while in use.

e. Inside of buildings, cylinders shall be stored in a well-protected, well-ventilated, dry location, at least 20 feet from highly combustible materials.

f. Oxygen cylinders in storage shall be separated from fuel-gas cylinders or combustible materials by a minimum of 20 feet, or by a noncombustible barrier at least 5 feet high having a fire-resistance rating of at least one half hour.

Figure 11

EMPTY
OXYGEN
FUE

Objective 15

Rules for moving compressed gas cylinders

a. Valve protection caps shall not be used for lifting cylinders from one vertical position to another.

b. Unless cylinders are firmly secured on a special carrier, regulators shall be removed and valve protection caps put in place before cylinders are moved.

c. Cylinders shall be moved by tilting and rolling them on their bottom edges.

d. When work is finished, when cylinders are empty, or when cylinders are moved at any time, the cylinder valve shall be closed.

e. Cylinders containing oxygen, acetylene, or other fuel gases shall not be taken into confined spaces.

Objective 16

General steps for handling any emergency situation

a. **Step 1:** Determine the type of emergency.

b. **Step 2:** Notify the appropriate medical or law-enforcement authority.

Examples: Ambulance, fire department, police

c. **Step 3:** Notify your supervisor.

d. **Step 4:** Provide basic first aid, or seek assistance from others until proper authorities arrive.

Objective 17

General guidelines for first aid emergencies

a. Before administering first aid, always have a reason for what you do.

b. Reassure the injured person that everything possible is being done.

Note: Hearing the concerned voice of a co-worker is psychologically comforting to an injured person and can actually lessen the degree of traumatic shock.

c. Make accurate notes about the accident, including the victim's name, the time, place, cause or nature of the accident, and any first aid that was administered.

d. Do not notify the victim's family; this is the responsibility of the school, the job site supervisor, or the medical facility.

e. Report all accidents and injuries to your instructor or job site supervisor, no matter how minor they may seem.

Objective 18

Descriptions of basic first aid procedures for various emergency situations

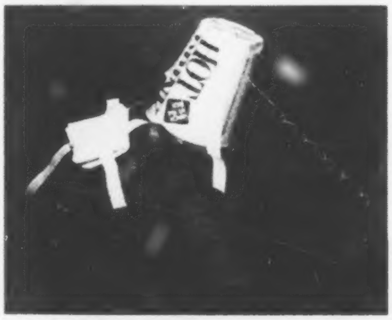
Note: In the event of severe injury or illness, notify your supervisor, call an ambulance, paramedics, or a doctor, and give the victim basic first aid until help arrives.

Caution: Given the increased awareness of diseases carried by bloodborne pathogens, hepatitis B (HBV), human immunodeficiency virus (HIV) and others, the U.S. Department of Labor advises that universal precautions be observed any time blood or other human body fluid is present. This precaution requires employers and employees to assume that all human blood and specified human body fluids are infectious for HIV and HBV and other bloodborne pathogens. Where it is impossible to determine the type of body fluid present, all body fluids are to be considered potentially infectious.

a. **Eye injury**

- Minor—Have the victim close his or her eyes; put a piece of moist cotton over the closed lid; place a bandage over the cotton; get the victim to a doctor as soon as possible.
- More severe injury—Apply a sterile dressing, bandage loosely, and get medical help immediately.

Figure 12



Note: Never permit the victim of an eye injury to rub his or her eye. Even though damage may be confined to one eye, it is sometimes best to bandage both eyes with a sterile dressing so the victim will not have a tendency to move the damaged eye.

- Chemical injury—Flush eyes immediately at an eye-flushing station, or use a bottled, portable flushing solution; then seek immediate medical assistance.

b. **Bleeding**

Note: Always put on disposable gloves before touching blood or handling blood products.

Figure 13

- Minor bleeding—Apply antiseptic solution or cream and dress wound with sterile bandages.
- Severe bleeding—Elevate the wound and apply pressure dressing or manual pressure to the wound.

c. **Burns**

- Chemical—Flush skin thoroughly with clean water and seek medical attention.
- Electrical—Locate both the entrance and exit burns; cool with a damp compress, then cover with dry, sterile dressing; cover the victim with a blanket and elevate the feet and legs to prevent shock and loss of body heat.
- First-degree—Hold under cold water, then apply dry, sterile dressing.
- Second-degree—Cool with a damp compress, taking care not to break the blisters, then cover with a dry, sterile dressing to prevent infection.
- Third-degree—Cool with a damp compress and then cover with a dry, sterile dressing; cover the victim with a blanket, elevate feet and legs to prevent shock and loss of body heat.

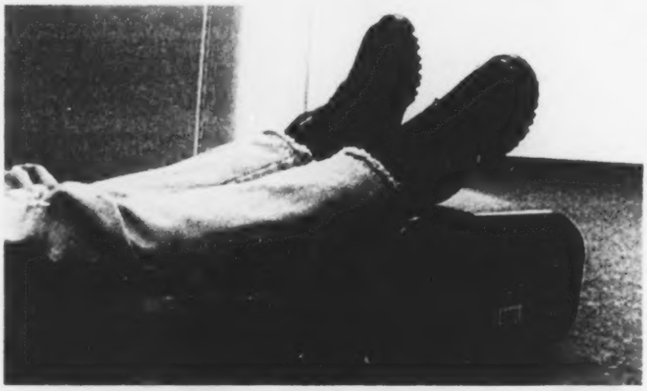
d. **Traumatic shock**

Note: Traumatic shock may occur within any time period following an injury. Although the injury itself may not be life threatening, the onset of shock resulting from the injury can be fatal.

- Recognize signs and symptoms of traumatic shock.
  - Early stages
    - Pale or bluish skin that is cool to touch
    - Moist, clammy skin if perspiration has occurred
    - General weakness
    - Rapid, weak pulse
    - Rapid, shallow, possibly irregular breathing
    - Restlessness or anxiety
    - Vomiting or nausea
    - Excessive thirst
  - Late stages
    - An attitude of not caring
    - Unresponsiveness
    - Sunken eyes with dilated pupils
    - Spotty or mottled appearance of skin; bluish color to lips and nailbeds
    - Low body temperature; cool clammy skin
    - Loss of consciousness leading to death if untreated

- Lay victim down.
- Elevate victim's legs slightly.

Figure 14



- Cover to prevent loss of body heat.

Note: In some cases it may be necessary to have someone lie in close contact with the victim to conserve body heat.

e. **Falls**

- Head injury—Lay victim flat, then control bleeding and shock.
- Less severe falls—Check for injury and provide first aid as appropriate; do not move victim or allow victim to move if a neck or back injury is suspected.

Caution: If either neck or back is broken, moving the victim could sever or damage the spinal cord, causing immediate death or paralysis.

f. **Electrical accident**

Caution: If the victim is still in contact with a live electrical circuit, do not endanger yourself by touching the victim, or metal objects, water, or wet ground. You may become a victim yourself as the current passes through your body. Death can be instantaneous.

- Do not provide any medical assistance until all electrical current has been shut off.
- Administer CPR if necessary.
- Treat for traumatic shock.
- Treat for electrical burns.

Note: Always look for the entrance wound and exit wound of an electrical burn. Both may resemble a bull's-eye consisting of a central charred zone, a middle zone of gray tissue, and an outer red zone.

g. **Heat exhaustion**

- Recognize the signs and symptoms of heat exhaustion:
    - — Profuse perspiration
    - — Pale, clammy skin
    - — Rapid, weak pulse
    - — Rapid, shallow breathing
- Immediately move victim to a cool place.
- Lay victim flat.
- Elevate victim's feet slightly.
- Remove as much of the victim's clothing as possible.
- Sponge victim with cool water.

h. **Heat stroke**

Note: Heat stroke is a true emergency. Act quickly or the victim will suffer brain damage or death.

- Recognize the signs and symptoms of heat stroke:
    - — Little or no perspiration
    - — Hot, flushed skin
    - — Rapid, weak pulse
    - — Rapid, shallow breathing
- Move victim immediately to a cool location.
- Cool victim as quickly as possible.

    Note: Do not take time to remove a victim's clothing until after initial cooling, such as spraying the victim with a garden hose, pouring the contents of a drinking water container over the victim, or immersing victim in a nearby stream or pond.

- Rub ice on victim's extremities.

i. **Mild hypothermia**

- Recognize the signs and symptoms of mild hypothermia:
    - — Shivering
    - — Complaints of being cold
    - — Loss of coordination
    - — Psychological withdrawal and apathy

- Get the victim out of cold, wet conditions.
- Replace wet clothing with dry clothing, or add insulation.
- Place victim in warm environment.
- Offer warm liquids or food only if victim is fully conscious.

j. **Moderate hypothermia**

- Recognize the signs and symptoms of moderate hypothermia:
  - — Listlessness, mental confusion, refusal to recognize problem
  - — Uncontrollable shivering
  - — Slurred speech
  - — Stumbling
- Cover victim at the site rather than walking to shelter.
- Treat victim gently and avoid unnecessary jostling or movement.
- Do not allow victim to exercise or move.
- Check victim for other injury, including frostbite.

k. **Severe hypothermia**

- Recognize the signs and symptoms of severe hypothermia:
  - — Unresponsiveness
  - — Decreased pulse and respiration
  - — Cessation of shivering
  - — Physical collapse
- Treatment should be attempted only if victim cannot be evacuated for professional emergency care.
- Deliver warmth to head, neck, armpit, and groin areas by application of warm water bottles, warmed blankets, or another warm body.

l. **Animal bite**

Note: First aid for animal bites is similar to any other wound, except for the need to be aware of the possibility of rabies infection.

- Cleanse wound thoroughly with soap and water; apply antiseptic.
- Cover bite wound with a sterile dressing and bandage.
- Seek medical attention, especially if the bite is on the face, head, or neck areas.

m. **Insect stings**

Note: In case of a bee sting, the insect's stinger likely will still be imbedded in victim's skin. Scrape stinger sideways to remove. Never pinch the stinger to remove as this actually will inject more toxin into the wound.

- Ordinary reaction—Wash wound with soap and water and apply ice to reduce swelling
- Allergic reaction

  Note: A victim with an allergic reaction to a bee sting is suffering from anaphylactic (respiratory arrest) shock and needs prompt treatment with epinephrine by injection or inhalation.

  — If possible, immediately evacuate the victim to a hospital or physician's office.

  Note: Have someone call ahead to notify the party of the situation and your planned arrival.

  — If transportation is not immediately available, lay the victim down or help the victim to a position in which he or she can breathe more easily.

  — Elevate the victim's legs if possible.

  — While waiting for emergency aid, remove the stinger and perform first aid actions for an ordinary sting.

n. **Snake bite**

- Nonpoisonous

  — Cleanse wound with plain water and soap.

  — Cover with sterile dressing.

  — Seek medical attention.

- Poisonous—Pit viper

  Note: Within the medical community there is a vigorous controversy over the advisability of using antivenin injections in the treatment of snake bites originating from copperheads, rattlesnakes, and cottonmouth (water moccasin). Although in the case of the coral snake, antivenin treatment is recommended, because of the conflicting opinions on the use of similar materials for pit viper bites, professional medical assistance is advisable and decisions on the use of antivenin should be left up to those professional individuals.

- Immobilize the victim.
- Have him or her lie down, and keep quiet.
- Do not give victim liquor.
- Apply a constricting band about the affected appendage just above the fang marks as soon as possible.

  Note: Under no circumstances should the constricting band be tight enough to block venous or arterial blood flow. Also, as edema (tissue swelling due to concentrations of water and waste material) builds, the band should be moved further from the wound periodically.

- Apply suction as quickly as possible to wounds to remove venom.

  Note: Suction cups, "Extractor" devices, and mouth suction (be aware of cautions on bloodborne pathogens) are recommended to remove as much venom as possible. Suction should be continued up to four hours after the bite, although the amount of venom removed by this method will be sharply reduced after the first 15 minutes. Still, as pit viper venom degenerates tissue and blood cells near the wound, suction removal of this waste material will be helpful in preventing the victim's body from having to filter this material through the lymphatic and renal systems.

- Apply hot and cold compresses, alternated every three to five minutes.

  Note: Raising the temperature of venom tends to break it down, and lowering temperatures tend to cause the capillary system to contract. The continual differing stimuli help provide fresh oxygenated blood flow to the wound area and tend to prevent additional tissue damage.

- Seek medical attention at once.

• Poisonous—Coral snake

Note: The venom of the coral snake is similar to that of the cobra in that it attacks the nervous system, unlike venom of pit vipers which attacks the blood and circulatory system. Because of this immediate medical attention and administration of antivenin is necessary. Death can come rapidly.

- Immobilize the victim. Have him or her lie down and keep quiet.
- Apply arterial tourniquet (tight enough to stop blood flow) up to 30 minutes.
- Seek medical attention at once for antivenin administration.

o. **Tick bites**

- Carefully remove an imbedded tick with tweezers by grabbing the tick as close to the skin as possible and pulling gently straight out.

  Note: Removing the tick with the thumb and forefinger carries the risk of crushing the tick and actually injecting the victim with the juices of the tick.

- Wash area with soap and water.
- Use a topical antiseptic and be alert for signs of tick-borne diseases for several weeks.

  Note: Some ticks are carriers of Lyme disease and Rocky Mountain Spotted Fever.

p. **Spider bites**

- Apply cold water or ice; a topical antiseptic may be used; take aspirin or acetaminophen for pain; and rest.

  Note: The bite of either the black widow or brown recluse spider is highly toxic and dangerous. If bitten by either of these species (or if you are not certain of the biting spider's identification) seek medical attention at once.

q. **Choking**

- Recognize the signs and symptoms of choking:
  - Victim clutches throat (universal sign of choking)
  - Victim has trouble speaking or breathing
  - Skin turns pale or bluish
  - Victim loses consciousness
- Perform the Heimlich maneuver

r. **Heart attack**

- Recognize the signs and symptoms of heart attack:
  - Chest pain that may radiate to the arms, neck, jaw, and upper back

    Note: Chest pain is the most important symptom of heart attack. It is reported in 80 to 90 percent of heart-attack victims.

  - Profuse sweating and chills

- — Nausea and vomiting
- — Difficulty and pain in breathing
- — Weakness
- — Apprehension

Note: A victim of heart attack will often feel as though he or she is going to die.

- Help victim to a less painful position.
- Loosen victim's clothing around the neck and midriff.
- Apply CPR if required and you are qualified.

s. **Seizure**

- Help victim lie on the ground or floor if possible.
- Do not try to restrain victim.
- Clear area of hard or dangerous objects to protect the victim from self-injury.
- Remove victim's eyeglasses, if applicable, and loosen clothing in the head and neck area.
- Turn victim to the side to allow saliva to drain from the mouth.
- Transport victim to a hospital or doctor's office after seizure has passed.

Objective 19

Treating the victim of electrical shock

a. Safely remove victim from contact with the source of electricity using the following procedure:

Caution: Do not touch the electrical circuit or the victim unless the power is off or you are insulated.

- Turn off the electricity, using a switch or circuit breaker, or cut cables or wires with a wood-handled axe or insulated cutters.

Caution: Be aware that throwing the circuit breaker on systems with auxiliary or backup power only momentarily deenergizes the system.

Note: Rescue must be effected quickly. After five minutes, the chances of saving the individual greatly decrease.

- As an extra precaution, and only after the electricity has been turned off, use a stick, rope, leather belt, coat, blanket, or any other dry, nonconductor of electricity to separate the victim from the electrical circuit.

Caution: Do not take hold of the victim with your bare hand.

b. Call for assistance.

- Others in the area may be more knowledgeable than you about treating the victim.
- Another person can call for professional medical help while you administer first aid.

c. Check the victim's breathing and heartbeat.

Note: Time is life at this point!

- If a pulse is detectable but breathing has stopped, administer mouth-to-mouth resuscitation until the victim resumes breathing or medical help arrives.
- If the heartbeat has stopped, administer cardiopulmonary resuscitation (CPR), until the victim's heartbeat resumes or medical help arrives—but only if you have been trained in the proper technique.

Caution: CPR can sometimes cause more harm than good to a victim unless the person administering the first aid has been trained in the proper procedure.

- If both the heartbeat and breathing have stopped, alternate between cardiopulmonary resuscitation and mouth-to-mouth resuscitation, but again, only if you have been trained in this technique.

d. Administer first aid for burns.

- Cover your mouth and nose with a clean handkerchief to prevent breathing germs on the victim.
- Locate and treat both the entrance and exit burns.
- Cool burns with a damp compress and then cover with a dry, sterile dressing.

Caution: Do not attempt any other treatment of burns.

e. Administer first aid for traumatic shock.

- Lay victim down.
- Elevate victim's legs slightly above head level.
- Cover to prevent loss of body heat.

f. Continue treatment, but only within your ability, until medical help arrives.

Student Supplement 1—Lens Shade Selection Charts

Each student must use equipment with filter lenses that have a shade number appropriate for the work being performed for protection from injurious light radiation. The following is a listing of appropriate shade numbers from various operations.

Operation	Electrode Size—1/32 in.	Arc Current	Minimum(*) Protective Shade
Shielded Metal Arc Welding	Less than 3 3-5 5-8 More than 8	Less than 60 60-160 160-250 250-550	7 8 10 11
Gas Metal Arc Welding and Flux Cored Arc Welding		Less than 60 60-160 160-250 250-500	7 10 10 10
Gas Tungsten Arc Welding		Less than 50 50-150 150-500	8 8 10
Carbon Arc Cutting—Air	Light Heavy	Less than 500 500-1000	10 11
Plasma Arc Welding		Less than 20 20-100 100-400 400-800	6 8 10 11
Plasma Arc Cutting	Light Medium Heavy	Less than 300 300-400 400-800	8 9 10

Operation	Plate Thickness inches	Plate Thickness—mm	Minimum(*) Protective Shade
Gas Welding:			
Light	Under 1/8	Under 3.2	4
Medium	1/8 to 1/2	3.2 to 12.7	5
Heavy	Over 1/2	Over 12.7	6
Oxygen Cutting:			
Light	Under 1	under 25	3
Medium	1 to 6	25 to 150	4
Heavy	Over 6	Over 150	5

Footnote (*)—As a rule of thumb, start with a shade that is too dark to see the weld zone. Then go to a lighter shade that gives sufficient view of the weld zone without going below the minimum. In oxyfuel gas welding or cutting where the torch produces a high yellow light, it is desirable to use a filter lens that absorbs the yellow or sodium line in the visible light of the operation.

Student Supplement 2—A Systematic Look at First Aid

First aid can be defined as "immediate temporary care given the victim of an accident or suddenness or trauma until the services of a physician can be obtained."

The goal of first aid is to intervene actively to prevent further damage, to provide life support, and to begin effective treatment of the victim's condition, to minimize injury and prevent death. Although first aid is not a substitute for medical care, those trained in first aid are able to assess the nature and extent of an emergency and determine the best course of action to take until professional medical help arrives.

Scene Survey

First aid begins with a scene survey. Before approaching a victim, a survey of the area is necessary to determine if conditions surrounding the incident may place the victim and the rescuer in danger.

Primary Survey

Next, the primary survey will determine if lifesaving procedures must be immediately performed to save the victim's life. The primary survey involves checking the ABCs:

a: Is the AIRWAY open and the victim's neck stabilized?

The severity of spinal cord injuries has decreased 30-45 percent since awareness that the neck of an accident victim must be stabilized (support or immobilized) before moving the victim.

b: Is the patient BREATHING?

c: Is the victim's blood CIRCULATING? Is there a pulse? Or is there active bleeding?

Lifesaving procedures, including cardiopulmonary resuscitation (CPR) may be needed to provide basic life support when a victim has no pulse and is not breathing. The Heimlich maneuver aids choking victims by forcing ejection of obstructing material from the windpipe.

Secondary Survey

The secondary survey is a total body examination, a pulse check, respiration count (breaths per minute), and observation of skin conditions. **For electrical shock victims, this would be the time to search for both entrance and exit wounds.**

For severe medical problems, such as heart attack, stroke, or internal bleeding, the only outward sign of problems may be shock. Those in shock will have pale, cool and clammy skin; a rapid and weak pulse (over 100 beats per minute); more than 20 breaths per minute; weakness; and confused behavior. Treatment involves minimizing body heat loss, elevating the legs without disturbing the rest of the body, and getting help as quickly as possible.

Unit 4

Welding Tools and Equipment

Unit Contents

Student Components

Student Page

Learning Activities Sheet 4–3

Objective Sheet 4–5

Information Sheet 4–7

*Assignment Sheets

1—Identify Basic Hand Tools 31
2—Identify Basic Power Tools and Equipment 33

*Assignment Sheets are located in the Student Workbook.

Prerequisites:
None

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Research** Online resources regarding pricing and availability of hand and power tools. Visit www.swifco.com as one of your resources.

☐ 4. **Study** Information Sheet, Objectives 1 through 13.

☐ 5. **Do** Assignment Sheet 1, "Identify Basic Hand Tools."

☐ 6. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 7. If the evaluation is not satisfactory, repeat Steps 4 and 5.

☐ 7. **Study** Information Sheet, Objectives 14 through 22.

Optional

☐ 8. **View** Videotape entitled "Hand and Power Tool Safety."

☐ 9. **Do** Assignment Sheet 2, "Identify Basic Power Tools and Equipment."

☐ 10. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 11. If the evaluation is not satisfactory, repeat Steps 7, 8, and 9.

☐ 11. **Check** With instructor for any additional assignments to be completed.

☐ 12. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 13. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Unit 4 Welding Tools and Equipment

Objective Sheet

Unit Objective

After completing this unit, the student should be able to identify basic hand tools, power tools, and equipment, and state their characteristics. The student should demonstrate these competencies by completing the assignment sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to welding tools and equipment with their definitions.
2. Match driving and chipping tools with their characteristics and uses.
3. Match chisels, punches, and pry bars with their uses.
4. Select true statements about characteristics and uses of files.
5. Complete statements about types and uses of wire brushes.
6. Select true statements about vise-grip® clamps and their uses.
7. Match holding and anchoring tools with their uses.
8. Match alignment tools with their uses.
9. Complete statements about types of jacks and their uses.
10. Match pulling and lifting tools with their characteristics and uses.
11. Match measuring tools with their characteristics and uses.
12. Match layout tools with their characteristics and uses.
13. Match turning tools and wrenches with their uses.
14. Match pliers with their uses.
15. Match manual cutting and shaping tools with their uses.
16. Match manually-operated shop tools with their characteristics and uses.
17. Match power equipment with their characteristics and uses.
18. Match power saws with their characteristics and uses.
19. Match positioning equipment with their characteristics and uses.
20. Complete statements about rules for hand tool safety.

21. Select true statements about basic rules for safe use of power tools and equipment.

22. Select true statements about rules for tool and equipment maintenance.

*23. Identify basic hand tools. (Assignment Sheet 1)

*24. Identify basic power tools and equipment. (Assignment Sheet 2)

*Assignment Sheets are located in the Student Workbook.

Information Sheet

Objective 1

Terms and definitions

a. **Dies and punches**—Extremely hard, precisely shaped, metal molds used on a press brake for forming angles and shapes in metal

b. **Gauge**—The measured thickness of metal or wire, or an instrument to measure thickness

c. **Hydraulic shear**—A metal-cutting machine with operating power from fluid transport lines to provide a slower rate of operation than a mechanical shear

d. **Fixture**—A form or frame used to mass produce a part or to control distortion during a welding process

e. **Mechanical shear**—A metal-cutting machine with operating power from a clutch or a flywheel that provides high-speed operation

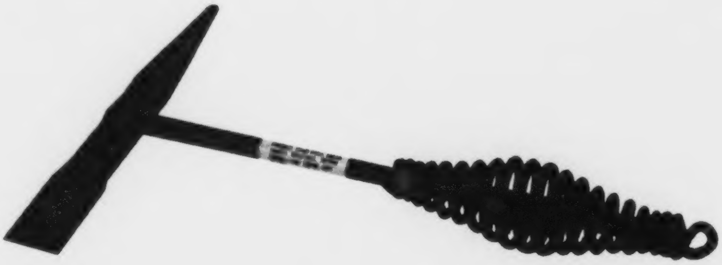
f. **Pneumatic shear**—A metal-cutting machine with operating power from compressed air transport lines to provide a slower rate of operation than a mechanical shear

Objective 2

Characteristics and uses of driving and chipping tools

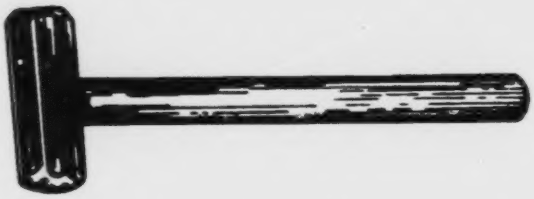
a. **Chipping hammer**—Used to remove slag and residue left on metals after welding or cutting

Figure 1



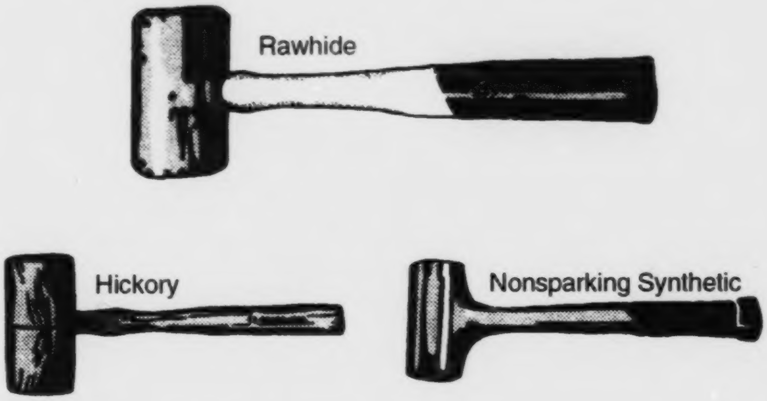
b. **Fitter's or engineer's hammer**—A heavy hammer with two driving heads used to drive wedges under and between materials; comes in weights of 40, 48, or 64 ounces

Figure 2



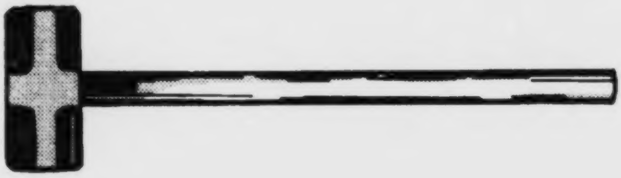
c. **Mallets**—Used where a metal hammer would dent or damage material; made of hickory, rawhide, lead, nylon, rubber, or other nonsparking material

Figure 3



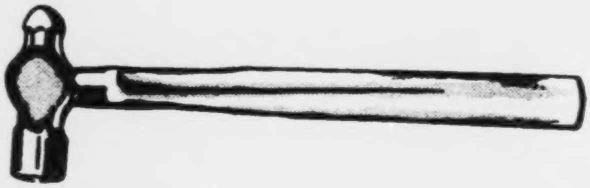
d. **Sledge hammer**—A long-handled hammer used when more driving force is needed than a smaller hammer can deliver; comes in weights of 2 to 20 pounds

Figure 4



e. **Ball peen hammer**—A general purpose hammer with a curved face and a rounded head; comes in weights from 4 to 48 ounces, and is usually used with one hand

Figure 5



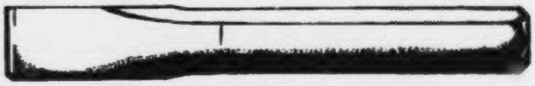
Note: The peen end is used for bending, shaping, and cutting metal.

Objective 3

Chisels, punches, and pry bars and their uses

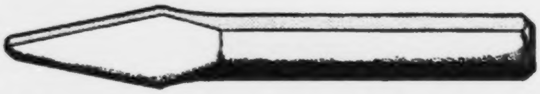
a. **Cold chisel**—Used for cutting metal, rivets, nuts, and bolts

Figure 6



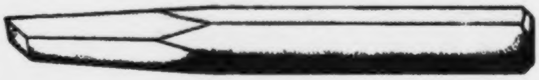
b. **Cape chisel**—Used for cutting keyways in metals

Figure 7



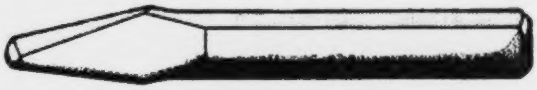
c. **Diamond-point chisel**—Used for cutting V-grooves and cleaning out inside corners

Figure 8



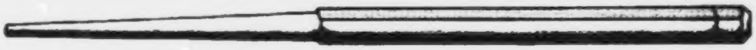
d. **Round-nose chisel**—Used for cutting U-shaped grooves in metal

Figure 9



e. **Drift punch**—Used for driving out straight or tapered pins

Figure 10



f. **Aligning pry bar**—Used for prying, positioning, and aligning parts in fit up

Figure 11

g. **ID stamp**—Used to identify the welder who completed the work

Note: The welder's ID is usually assigned by the employer, and can be all letters or numbers, or a combination of the two.

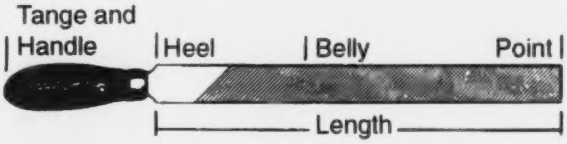
Figure 12

Objective 4

Characteristics and uses of files

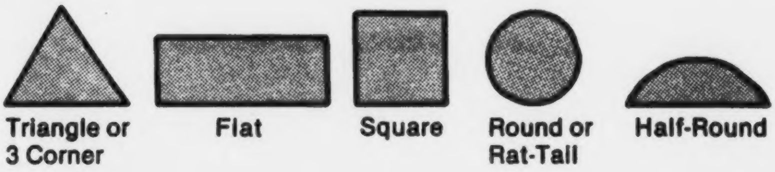
a. Files are used manually to remove metal stock.

Figure 13


Tange and Handle
Heel
Belly
Point
Length

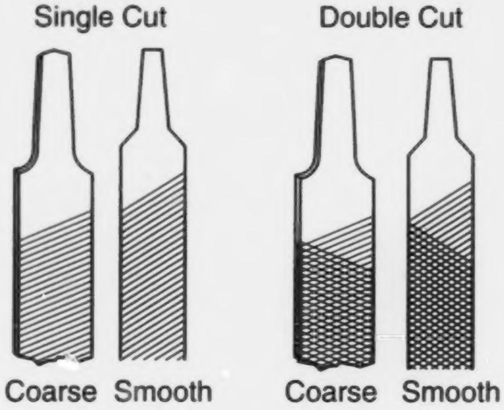
b. The shape of a file may be angular, flat, square, round or rat-tail, or half-round to provide a shape to match the job need.

Figure 14


Triangle or 3 Corner
Flat
Square
Round or Rat-Tail
Half-Round

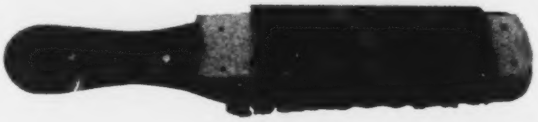
c. Basic file cuts range from single-cut coarse to double-cut smooth to provide textures that produce specific finishes.

Figure 15



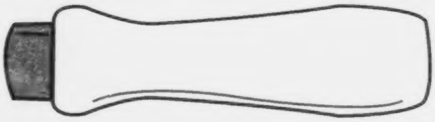
d. A card file is used to clean a file.

Figure 16



e. A file handle is used to cover the tang of a file and protect against injury.

Figure 17



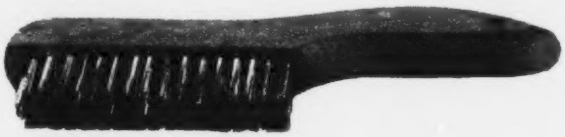
Objective 5

Types and uses of wire brushes

a. Wire brushes are used for cleaning a weld area before or after welding.

b. Wire brushes have steel wire bristles or stainless steel bristles with shoe horn shape or straight handles.

Figure 18

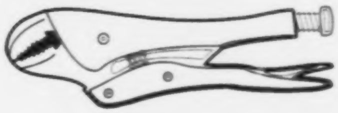


Objective 6

Vise-grip® clamps and their uses

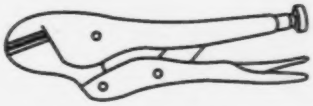
a. Use a curve-jaw clamp to hold round objects like brads and rivet heads.

Figure 19



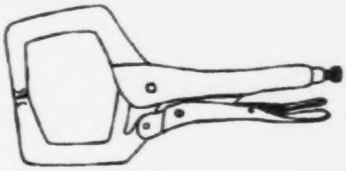
b. Use a straight-jaw clamp to hold nuts and bolts, but do not use a straight-jaw clamp on brass fittings.

Figure 20



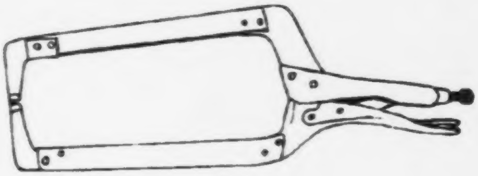
c. Use a C-clamp to hold irregular-shaped objects.

Figure 21



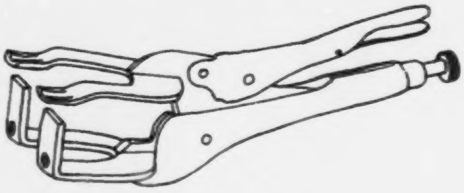
d. Use a long-reach C-clamp to hold long, irregular-shaped objects.

Figure 22



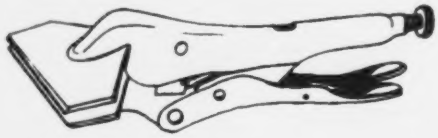
e. Use a welding clamp to hold metal workpieces, especially heated stock that needs to be quenched.

Figure 23



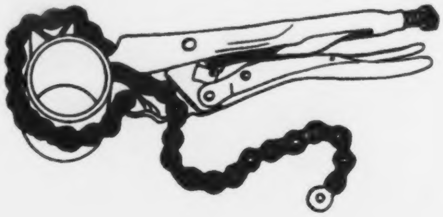
f. Use a sheet metal clamp to hold flat, thin pieces of sheet metal.

Figure 24



g. Use a chain clamp to hold or turn round stock, tube, or pipes.

Figure 25



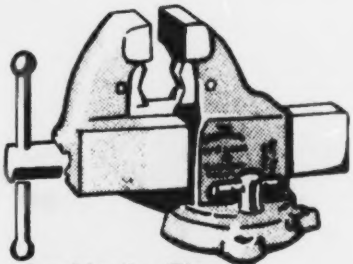
Objective 7

Holding and anchoring tools and their uses

a. **Vises**—Used to secure workpieces that cannot or should not be held with hand tools

Note: The combination/pipe vise is popular in welding shops because it can be used with both flat stock and pipe.

Figure 26

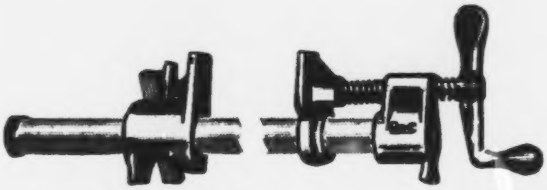


Combination/Pipe

393

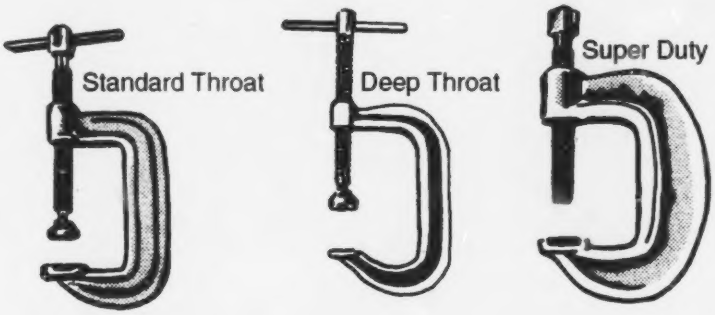
b. **Bar clamps**—Used to hold materials together until they can be joined by other means; bar clamps can hold longer, wider materials than vises can

Figure 27



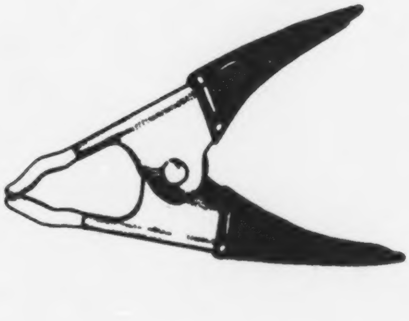
c. **Screw-type C-clamps**—Used to hold materials together until they can be joined by other means; these clamps are often used for distortion control

Figure 28



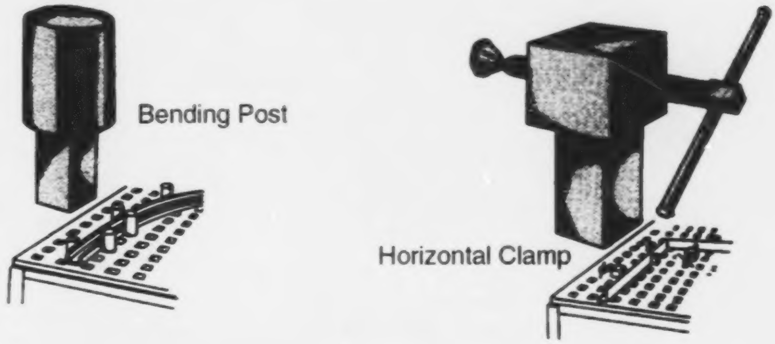
d. **Spring clamps**—Used for light duty to secure a tape line to a workpiece or to secure light detail material onto a main workpiece

Figure 29



e. **Platen table**—Used to eliminate welding and bending fixtures; has accessories to assist with layout and welding activities

Figure 30

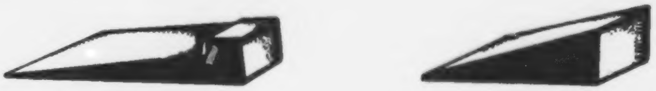


Objective 8

Alignment tools and their uses

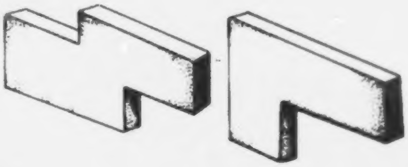
a. **Wedges**—Used to fit up two or more pieces of material by inserting a V-shaped end in between pieces so that striking the head or opposite end with a hammer will obtain vertical or horizontal alignment

Figure 31



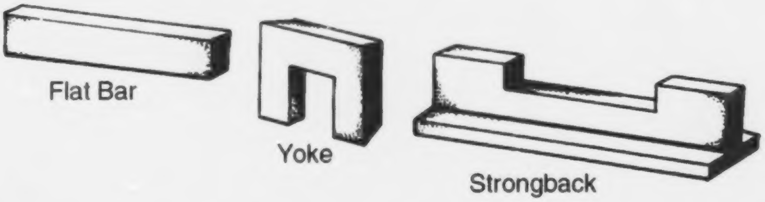
b. **Clip plates or dogs**—Used as a restraining device so that wedges can be applied and driven

Figure 32



c. **Flat bar, yoke, and strongback**—Used as restraining devices so that wedges can be applied and driven in situations where clip plates or dogs would not provide enough strength

Figure 33

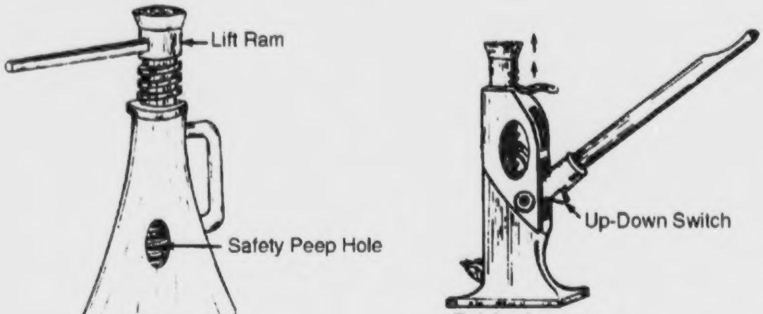


Objective 9

Types of jacks and their uses

a. Mechanical screw jacks and ratchet lever jacks are used to lift and hold materials in place at levels that make welding easier.

Figure 34

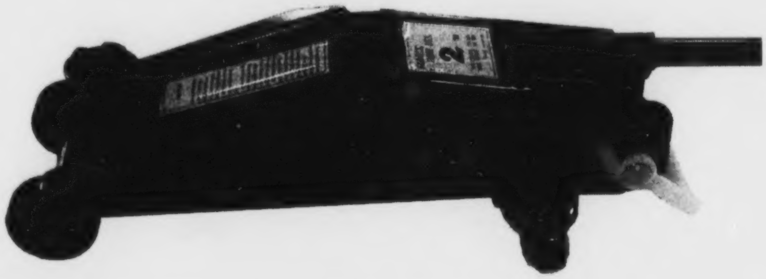


Screw Jack

Ratchet Lever or Railroad Jack

b. Hydraulic jacks are used for lifting or lowering loads too heavy to be safely handled by mechanical jacks.

Figure 35

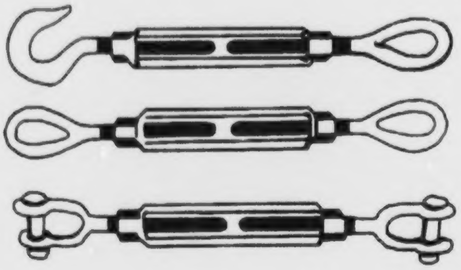


Objective 10

Pulling and lifting tools and their characteristics and uses

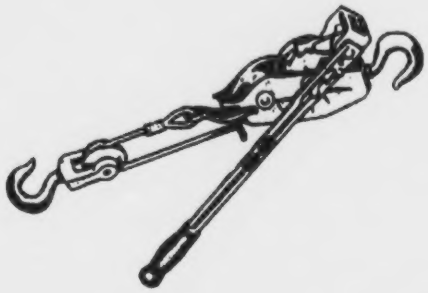
a. **Turnbuckles**—Used to adjust lengths of wire rope or steel rod; they are adjustable for taking up slack to induce a load or being slacked off to reduce a load

Figure 36



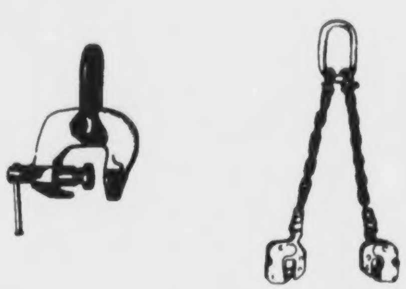
b. **Come-alongs**—Used as manually operated hoists; they are portable, easy to set up, and may be constructed with chain or cable

Figure 37



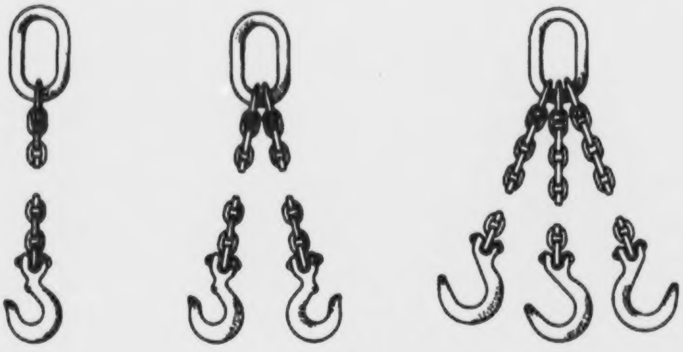
c. **Plate dogs**—Used to lift large, metal plates safely and move them from one place to another

Figure 38



d. **Slings**—Cables and hooks or chains and hooks used in single, double, triple, or quadruple arrangement for lifting and moving heavy objects

Figure 39

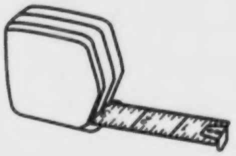


Objective 11

Measuring tools and their characteristics and uses

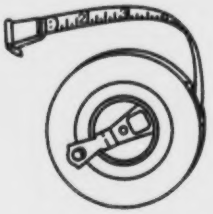
a. **Pocket tape**—Used to measure work points and straight line distances up to 25 feet

Figure 40



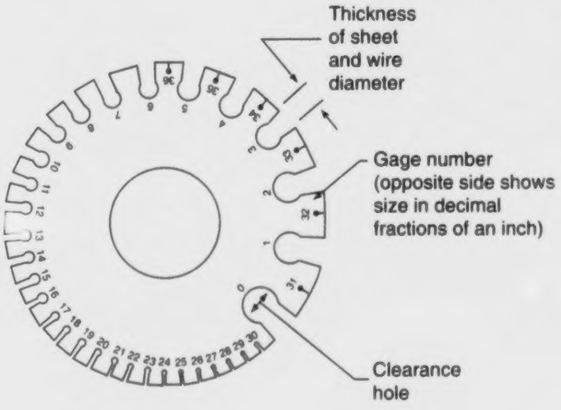
b. **Steel tape**—Used to measure work points and straight line distances greater then 25 feet

Figure 41



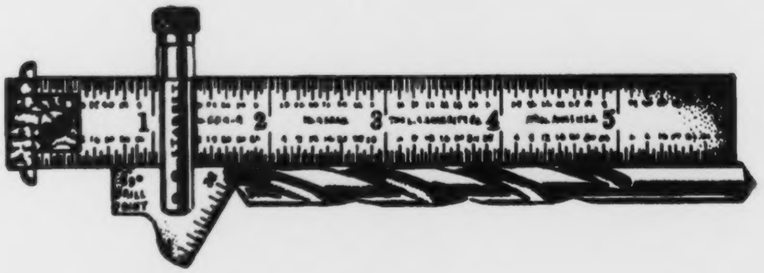
c. **American and U.S. standard metal gauges**—Used to measure the thickness or gauge of sheet metal, steel plate, and wire

Figure 42


Thickness of sheet and wire diameter
Gage number (opposite side shows size in decimal fractions of an inch)
Clearance hole

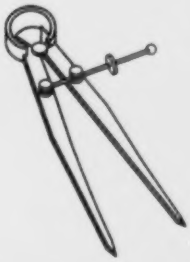
d. **Drill point gauge**—Used to assure that drill tips being sharpened are kept centered at an angle of 59° so that they will cut faster with less applied force

Figure 43



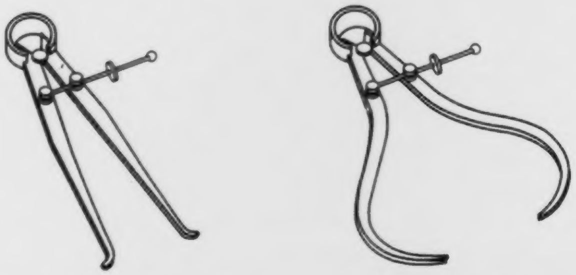
e. **Wing dividers**—Used to construct small circles and arcs and transfer measurements

Figure 44



f. **Calipers**—Used for straight line measurements, but especially used for critical inside/outside measurements of holes, casings, and pipes

Figure 45

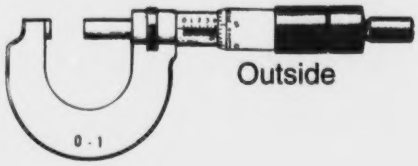


Inside Caliper

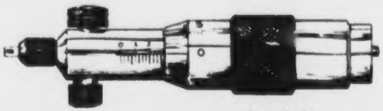
Outside Caliper

g. **Micrometers**—Used to measure the inside, outside, or depth of parts that require critical tolerances

Figure 46



Outside

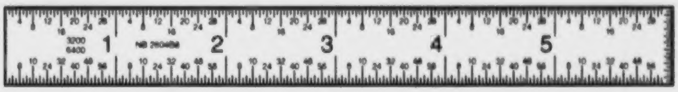


Inside

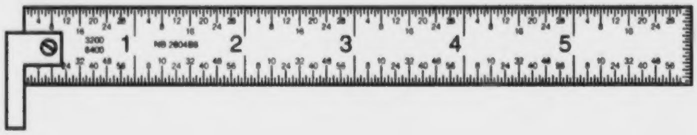
h. **Rules**—Measuring devices graduated in whole units and fractions for measuring distances ranging from fractions of an inch up to 48 inches

Figure 47

(1) Steel rule

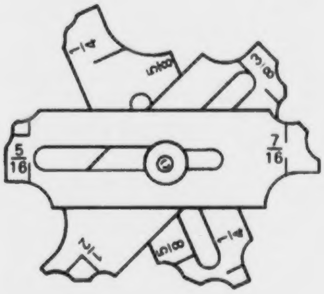


(2) Hook rule



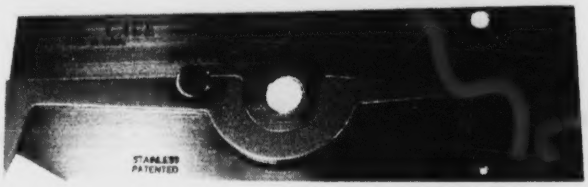
i. **Fillet gauge**—Used to measure fillet weld size

Figure 48



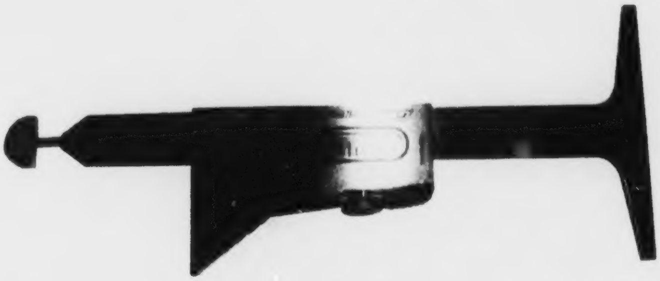
j. **Undercut gauge**—Used to measure undercut depth

Figure 49



k. **Hi-lo gauge**—Used to measure internal alignment and root weld spacing

Figure 50



Objective 12

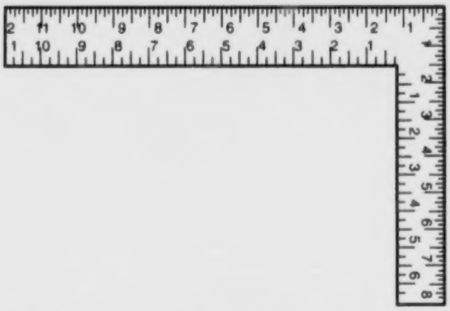
Layout tools and their characteristics and uses

a. **Levels**—Used to check surface alignment horizontally, vertically, or at angles

Figure 51

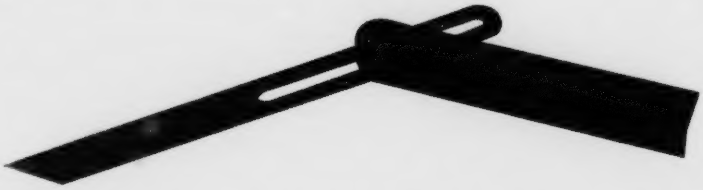
b. **Framing square**—Used primarily by fitters to check the trueness of pipe flanges, but it is also used for checking bevel square angles

Figure 52



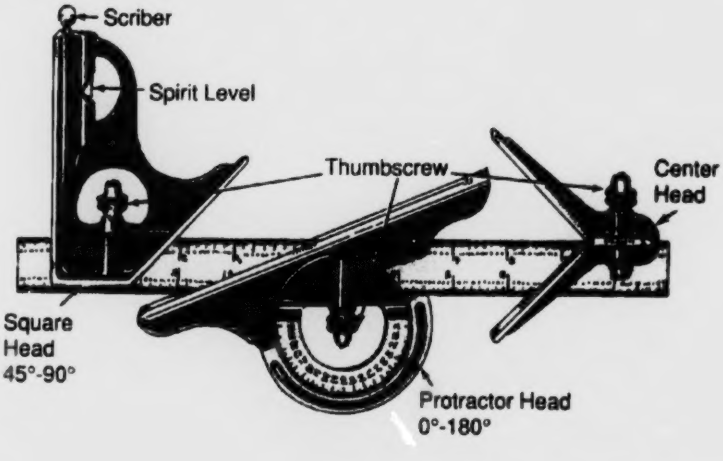
c. **Bevel square**—Used to lay out bevels or to check materials cut on a bevel

Figure 53



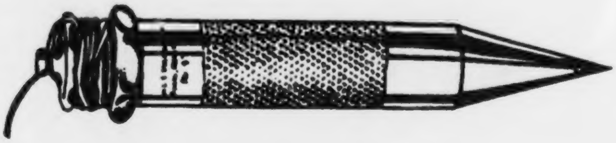
d. **Combination square**—Used to square detail materials with the square head used for finding 45° and 90° angles, the protractor head used for finding angles from 0° to 180°, and the center head used for finding the center or round materials

Figure 54


Scriber
Spirit Level
Thumbscrew
Center Head
Square Head 45°-90°
Protractor Head 0°-180°

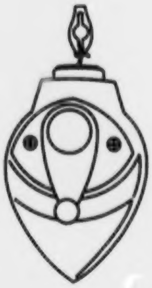
e. **Plumb bob and line**—Used to check vertical alignment of related members in a project or workpiece

Figure 55



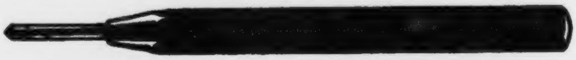
f. **Chalk line**—Used to check for straightness in plate and structural metals by permitting a chalk line to be snapped onto the surface of a workpiece

Figure 56



g. **Center punch**—Used to make puncture marks, to locate the centers of holes, or to establish work points or center lines on materials

Figure 57



h. **Prick punch**—Used most often to make punch marks along layout lines to provide permanent references for chalked or scribed lines that might wear off in handling

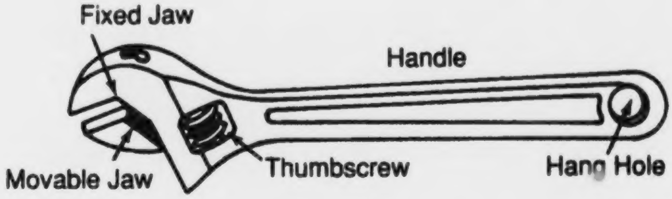
Figure 58

Objective 13

Turning tools and wrenches and their uses

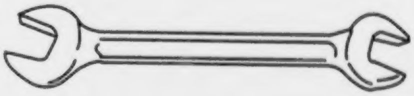
a. **Adjustable wrench** (Crescent wrench)—Used to tighten or loosen different sizes of nuts and bolts

Figure 59



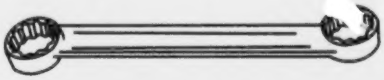
b. **Open-end wrench**—Used to tighten or loosen specific sizes of nuts and bolts

Figure 60



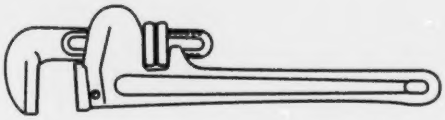
c. **Box-end wrench**—Used to tighten or loosen specific sizes of nuts and bolts, but the head has closer control of the gripping surfaces than other types of wrenches

Figure 61



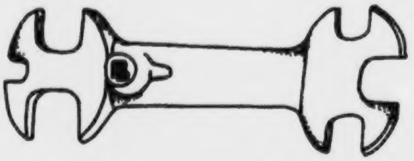
d. **Pipe wrench**—Used primarily for fitting up pipe, but handy for holding and aligning because of its vise-like adjustable jaws

Figure 62



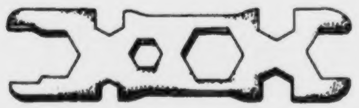
e. **Cylinder wrenches**—Used specifically for tightening or loosening cylinder connections on oxyacetylene equipment because adjustable wrenches can easily damage the brass fittings used on oxyacetylene equipment

Figure 63



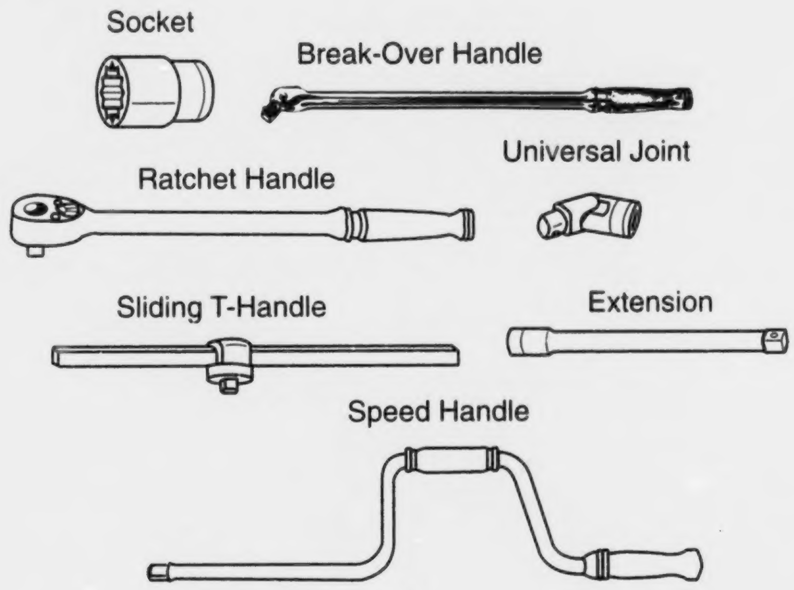
f. **Torch wrenches**—Used specifically for tightening or loosening torch connections because adjustable wrenches or pliers can damage brass fittings

Figure 64



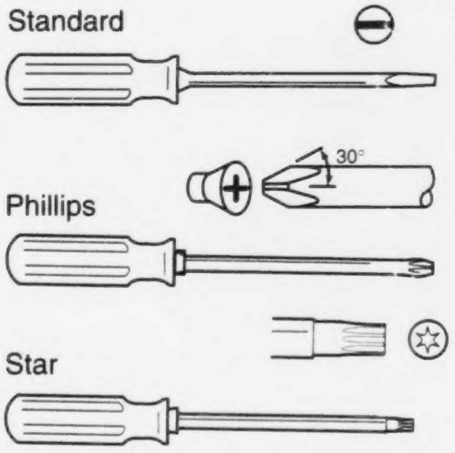
g. **Socket wrench sets**—Used with a variety of socket sizes and handles to tighten or loosen different sizes of nuts and bolts that may be difficult to reach or require extra torque to tighten or loosen

Figure 65


Socket
Break-Over Handle
Universal Joint
Ratchet Handle
Sliding T-Handle
Extension
Speed Handle

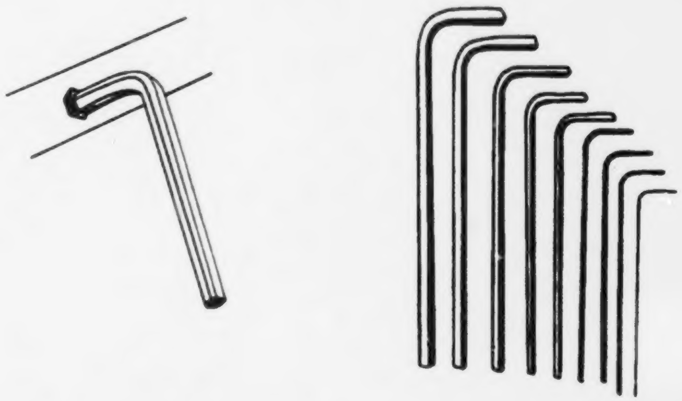
h. **Screwdrivers**—Used to tighten or loosen specific types of screws, bolts, and other anchoring devices

Figure 66



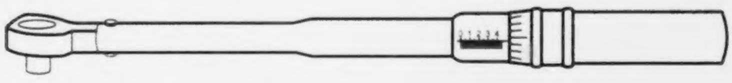
i. **Allen wrenches**—Key-type wrenches used to tighten or loosen specific sizes of Allen screws or bolts

Figure 67



j. **Torque wrench**—Used to tighten bolts to a specified value

Figure 68

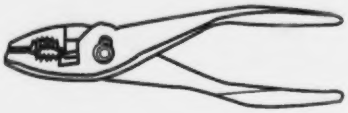


Objective 14

Pliers and their uses

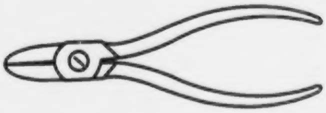
a. **Slip joint**—Used for handling hot metal or materials

Figure 69



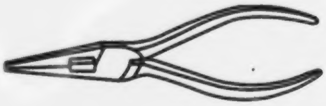
b. **Diagonal cutters**—Used for cutting small diameter wire, especially the wire used in gas metal arc welding

Figure 70



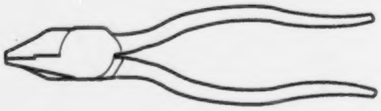
c. **Needle nose**—Used for cleaning cups and nozzles, for cutting small diameter wire, for holding and bonding, and for general work around gas tungsten arc welding

Figure 71



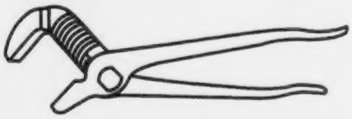
d. **Lineman's** (side cutters)—Used to cut large diameter wire, for holding, and for general work around submerged arc welding

Figure 72



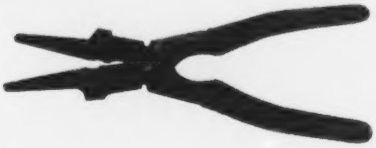
e. **Channel lock**—Can be adjusted to hold a variety of metal thicknesses

Figure 73



f. **Mig**—A multipurpose tool that can work as a wire cutter, a hammer or pliers, and can be used to clean and remove nozzles, and remove contact tips

Figure 74

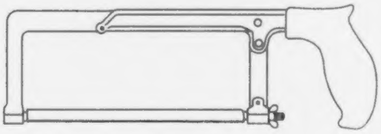


Objective 15

Manual cutting and shaping tools and their uses

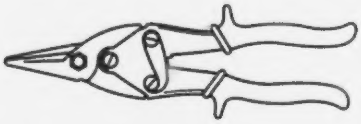
a. **Hacksaw**—Used to manually cut or separate metal

Figure 75



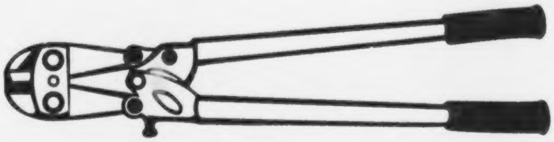
b. **Straight-cut snips**—Used to cut straight lines or curves on light-gauge metal

Figure 76



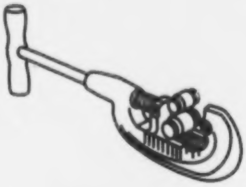
c. **Bolt cutters**—Used to cut small diameter nuts, bolts, rod, and chain

Figure 77



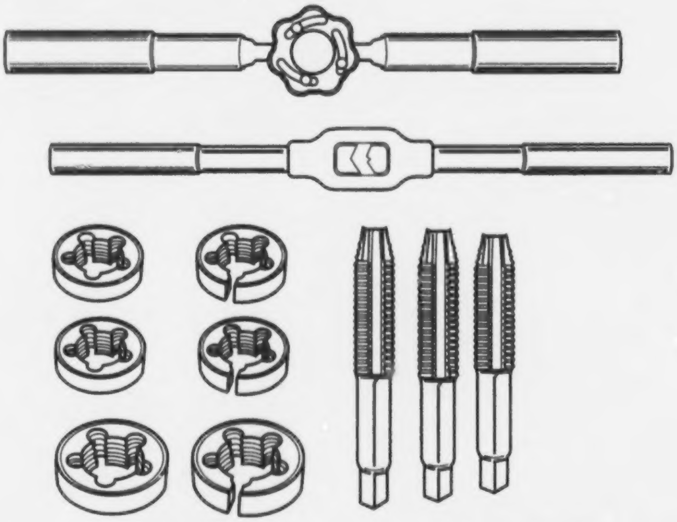
d. **Pipe cutters**—Used for cutting small-diameter pipe or tubing

Figure 78



e. **Tap and die sets**—Used to cut inside threads (taps) in metal or to cut outside threads (dies) on pipe or other round stock

Figure 79

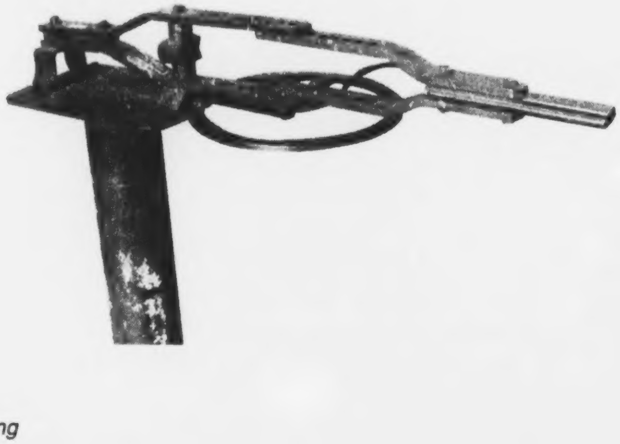


Objective 16

Manually-operated shop tools and their characteristics and uses

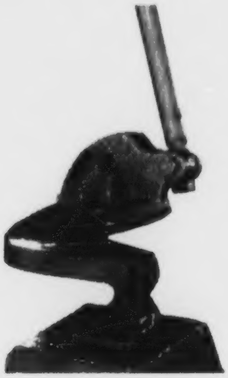
a. **Hossfeld bender**—Used to bend, form, and shape pipe, tubing, angle iron, flat bars, and straps

Figure 80



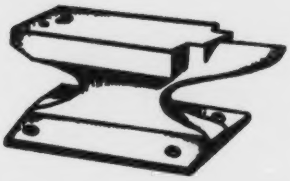
b. **Beverly shear**—Lever operated bench tool that makes distortion free cuts in straight or curved patterns on light to heavy metals

Figure 81



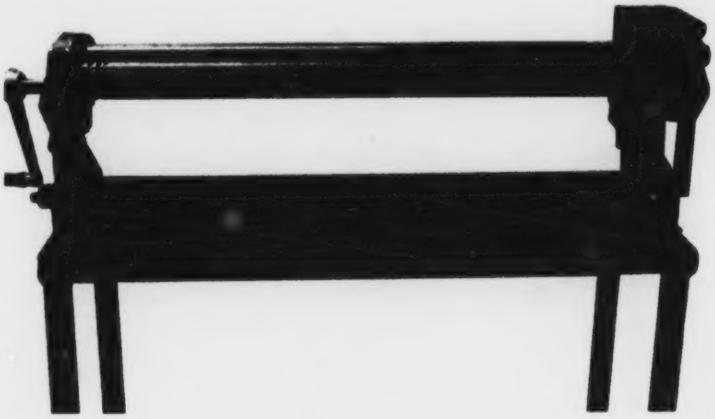
c. **Anvil**—An iron or steel block with both flat and curved surfaces for shaping metals that are hammered or peened against it

Figure 82



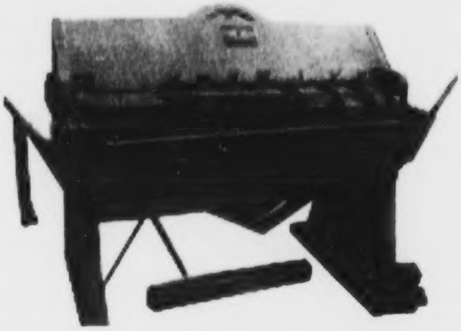
d. **Slip roller**—Used to form cylinders, reverse curves, and radius bends of sheet metal

Figure 83



e. **Floor brake**—Used for box, pan, and reverse bending of sheet metal

Figure 84

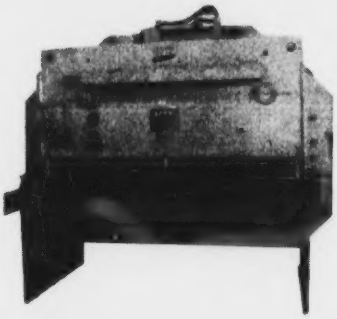


Objective 17

Power equipment and their characteristics and uses

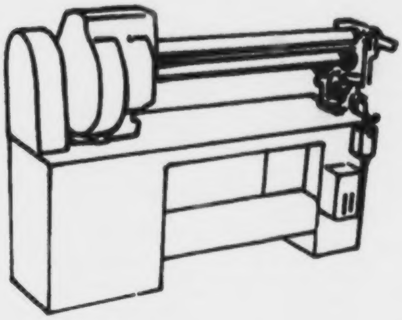
a. **Power shear**—Uses mechanical, hydraulic, or pneumatic power to cut all gauges of metal

Figure 85



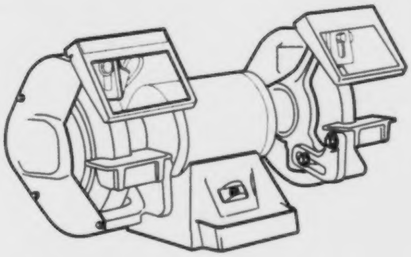
b. **Power roll**—Used to shape both plate and structural metals into needed forms

Figure 86



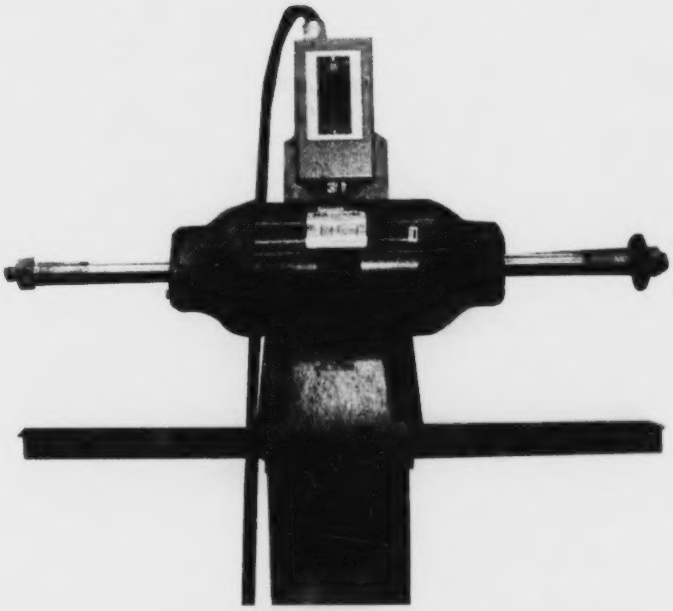
c. **Bench grinder**—Used for grinding all forms of metal; can be used on a pedestal

Figure 87



d. **Pedestal buffer**—Used to polish or buff metals with wire, brush, or cloth wheels

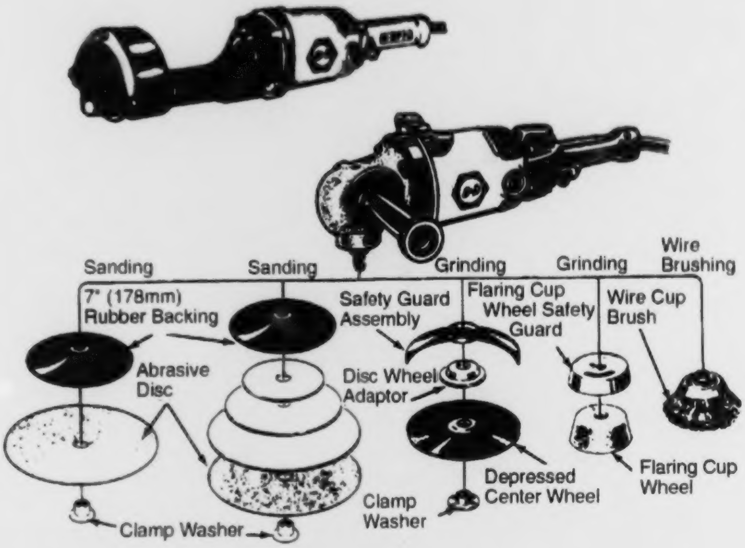
Figure 88



412

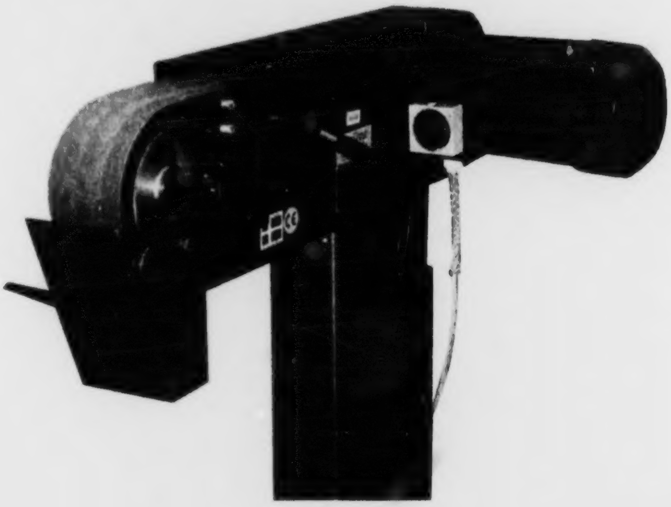
e. **Angle and straight grinders**—Generally used with attachments for cleaning joints before or after a welding process

Figure 89


Sanding
Sanding
Grinding
Grinding
Wire Brushing
7" (178mm) Rubber Backing
Safety Guard Assembly
Flaring Cup Wheel Safety Guard
Wire Cup Brush
Abrasive Disc
Disc Wheel Adaptor
Depressed Center Wheel
Flaring Cup Wheel
Clamp Washer
Clamp Washer

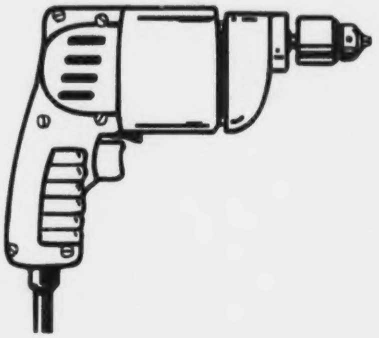
f. **Belt sander**—Used to grind or sand flat metal surfaces

Figure 90



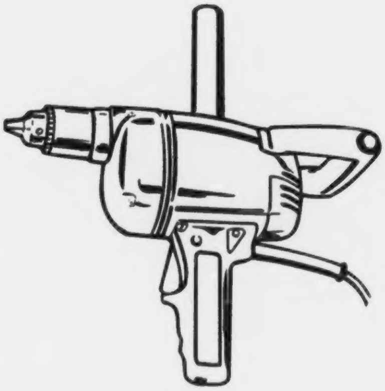
g. **Hand drill**—Generally used for light drilling jobs; designed with variable reversible speed in $^1/_4$", $^3/_8$", and $^1/_2$" sizes

Figure 91



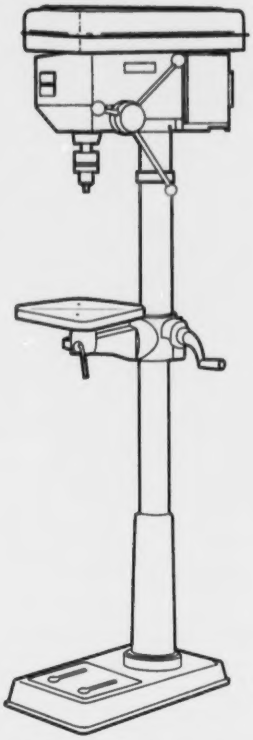
h. **Heavy duty hand drill**—Generally used for drilling thick materials; designed with variable or reversible speed in $^1/_2$", $^3/_4$", and $1^1/_4$" sizes

Figure 92



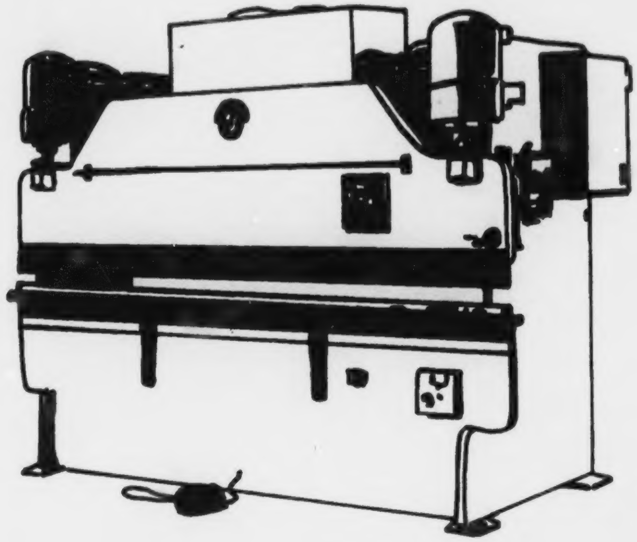
i. **Drill press**—Used for drilling holes in several pieces of metal at one time or drilling single holes in heavier metals

Figure 93



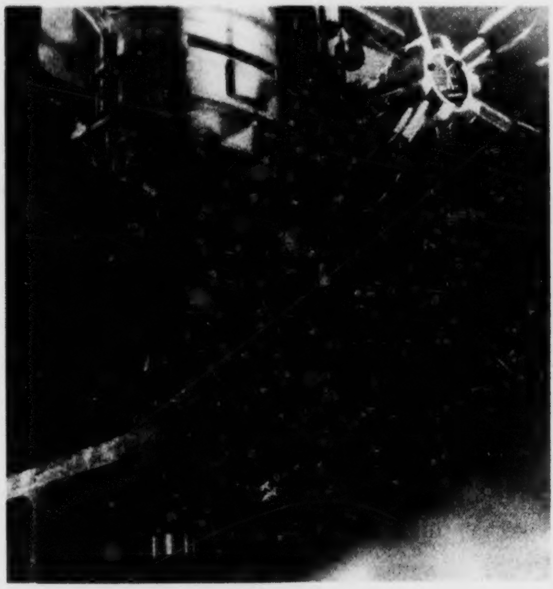
j. **Press brake**—Used with different dies and punches to press metal into a desired shape

Figure 94



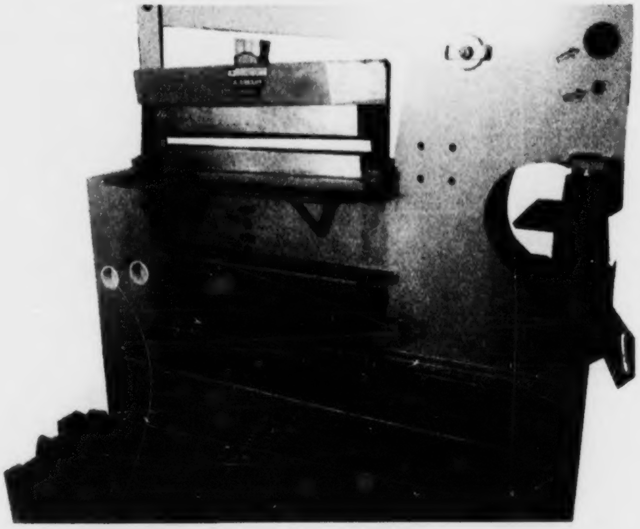
k. **Magnetic-based drill**—Used for drilling magnetic materials up to $1^1/_4$" thick; magnet on base of drill holds it in place while drilling

Figure 95



l. **Angle iron cutter, notcher, and bender**—Used to cut, notch, and bend angle iron

Figure 96



Objective 18

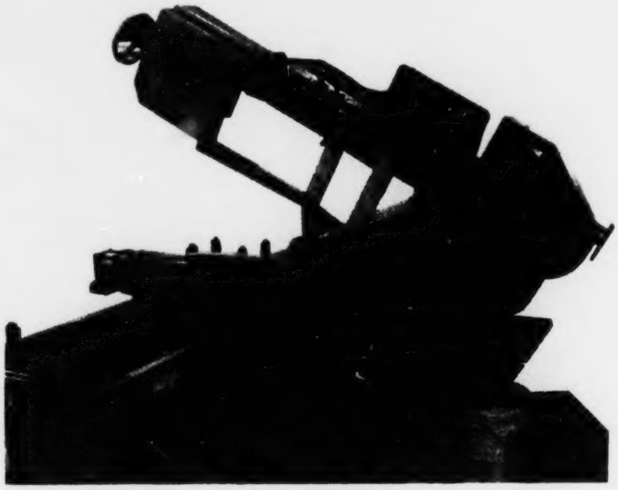
Power saws and their characteristics and uses

a. **Vertical band saw**—Used with a continuous cutting blade for cutting mild steel

Figure 97

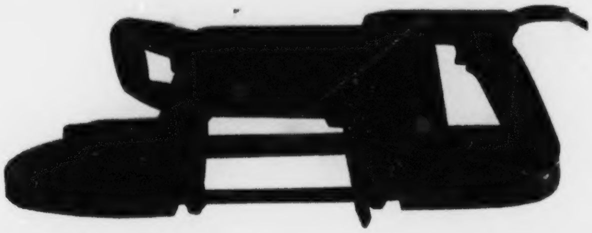
b. **Horizontal band saw**—Used with a continuous cutting blade to cut any length or type of metal

Figure 98



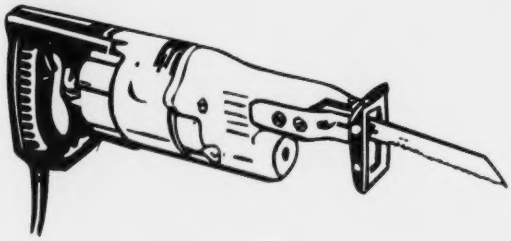
c. **Power hacksaw**—Used with a reciprocating blade to cut any length or type of metal

Figure 99



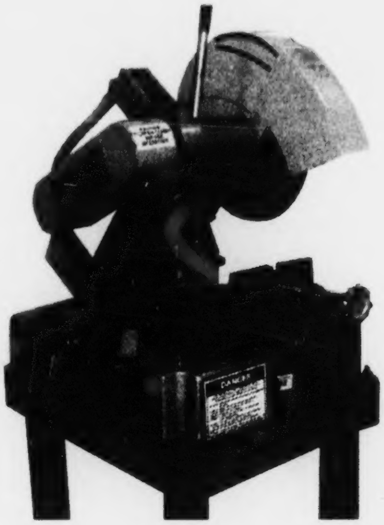
d. **Reciprocating saw**—Used like a key-hole saw with various types of blades to cut wood, metal, plastic, and even heavy steel

Figure 100



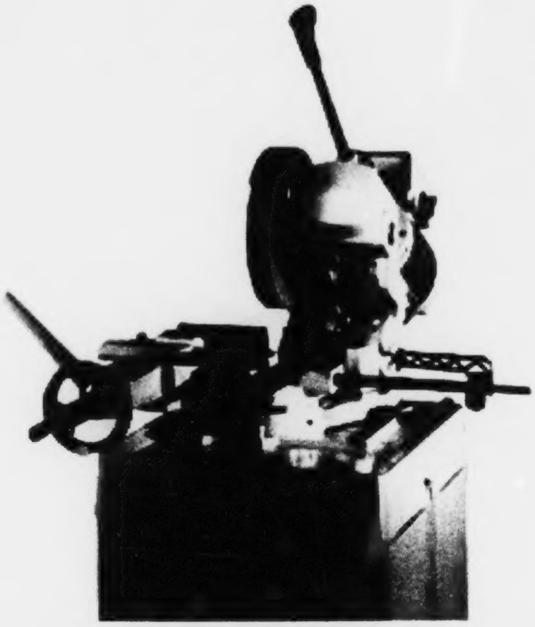
e. **Cut-off saw**—Used to cut heavier metal at different angles or in straight cuts

Figure 101



f. **Cold saw**—Used to cut a wide variety of material shapes and sizes at an angle between 0° and 45° without producing heat or distortion

Figure 102

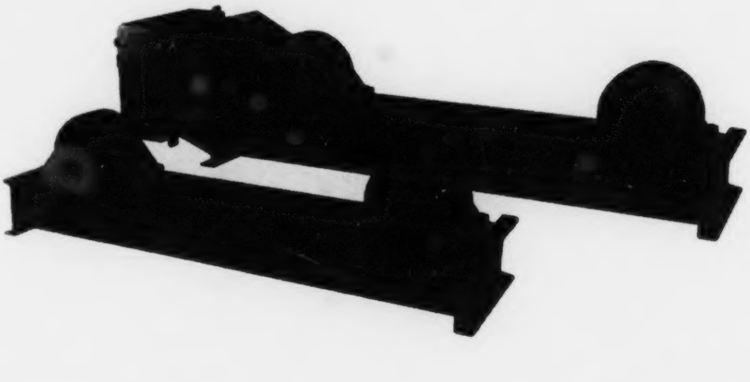


Objective 19

Positioning equipment and their characteristics and uses

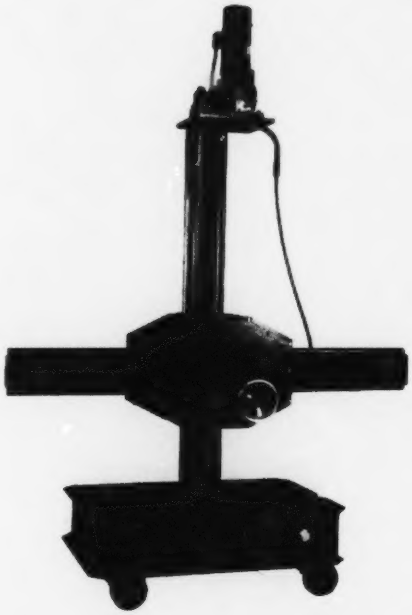
a. **Turning rolls**—Used in production or with automatic equipment that requires pipes or round objects to be rolled

Figure 103



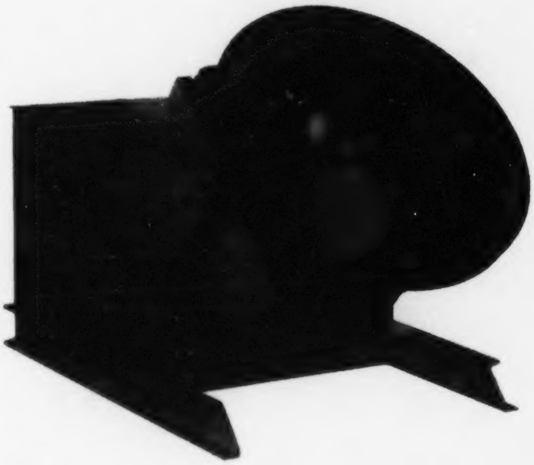
b. **Manipulators**—Used to control and position welding equipment on automatic positioners or turning rolls in production shops with automatic welding processes

Figure 104



c. **Positioners**—Used to secure and position objects being welded; can turn or rotate an object at a preset speed or can be controlled manually by an operator

Figure 105



Objective 20

Rules for hand tool safety

a. Never use a screwdriver as a prying tool.

b. Never use pliers to loosen or tighten nuts and bolts.

c. Never use any tool with a loose handle or defective part.

d. When using a screwdriver, support the work on a bench or against a solid surface.

e. When using a wrench, pull it toward yourself to prevent smashing your hand if the wrench should slip.

f. Never use a file without a handle.

g. Secure small parts or objects before working on them with hand tools.

h. Never strike the mushroomed head of a punch or chisel.

Objective 21

Basic rules for safe use of power tools and equipment

a. Do not use power tools until you have been instructed how to safely use them, and have permission from your instructor.

b. Check electrical cords and plugs before using electrical power tools, and check lines and connections before using air-operated tools.

c. When working with a drill press, always clamp the workpiece in place or it will spin with the drill bit.

d. Make sure shields and guards are securely in place before using power equipment.

e. Avoid walking into restricted safety zones marked off around power equipment.

f. When using extension cords with power equipment, make sure they are grounded and free of breaks or frays.

g. Do not wear loose or frayed clothing around rotating equipment.

h. Pay attention to safety signs and warning tags.

i. Know emergency shut-down procedures for all power equipment.

j. Keep tools clean and dry.

Information Sheet

Objective 22

Rules for tool and equipment maintenance

a. The number one rule for maintaining a tool or a piece of equipment is to use it only for its intended purpose.

b. Tag and report any tool or piece of equipment suspected of being faulty.

c. Record the type of service and date information placed on lubrication and maintenance schedules.

d. Always disconnect the power supply when performing maintenance on power tools and equipment.

e. Check tool rests on grinders daily.

f. Check grinding wheels daily and dress as needed.

g. Check oil pressure on shears before using them.

Unit Contents

Student Components

Student Page

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Objective Sheet 5–5

Information Sheet 5–9

*Assignment Sheet

1—Identify Selected Metals By Appearance, Color, and Corrosion Characteristics 35

*Job Sheets

1—Conduct Magnet Tests to Identify Common Metals Used for Welding 37
2—Conduct Chisel Tests to Identify Common Metals Used for Welding 39
3—Conduct Spark Tests to Identify Common Metals Used for Welding 41

*Assignment and Job Sheets are located in the Student Workbook.

Prerequisites:
None

Learning Activities Sheet

Student Name ____

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objectives 1 through 4.

☐ 4. **Do** Job Sheet 1, "Conduct Magnet Tests to Identify Common Metals Used for Welding."

☐ 5. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 6. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 1 and repeat Steps 3 and 4.

☐ 6. **Do** Job Sheet 2, "Conduct Chisel Tests to Identify Common Metals Used for Welding."

☐ 7. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 8. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 2 and repeat Steps 3 and 6.

☐ 8. **Study** Information Sheet, Objectives 5 through 13.

☐ 9. **Do** Assignment Sheet 1, "Identify Selected Metals by Appearance, Color, and Corrosion Characteristics."

☐ 10. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluator is satisfactory, continue to step 11. If the evaluation is not satisfactory, repeat Steps 8 and 9.

☐ 11. **Study** Information Sheet, Objectives 14 through 21.

☐ 12. **Research** Online resources regarding locations of nonferrous metal mines. Visit www.nationalgeographic.com/mapmachine as one of your resources.

☐ 13. **Study** Information Sheet, Objectives 22 through 24.

☐ 14. **Do** Job Sheet 3, "Conduct Spark Tests to Identify Common Metals Used for Welding."

☐ 15. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 16. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 3 and repeat Steps 13 and 14.

☐ 16. **Study** Information Sheet, Objectives 25 through 38.

Optional

☐ 17. **View** Videotape entitled "Prevention and Control of Distortion."

☐ 18. **Check** With instructor for any additional assignments to be completed.

☐ 19. **Take** Posttest provided by instructor. After the test has been evaluated, follow instructor's recommendations.

☐ 20. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next Learning Activities Sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Objective Sheet

Unit Objective

After completing this unit, the student should be able to identify metals by appearance, color, and corrosion characteristics, and conduct magnet tests, spark tests, and chisel tests to identify common metals used for welding. The student should demonstrate these competencies by completing the assignment and job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to basic metals and metallurgy with their correct definitions.
2. Select true statements about advantages of proper metal identification.
3. Match basic metals, alloys, and properties with their definitions.
4. Select true statements about metal identification tests and their characteristics.
5. Match mechanical properties of metals with their characteristics.
6. Match types of mechanical strengths with their characteristics.
7. Select true statements about physical properties of metals and their characteristics.
8. Solve problems about steel identification systems and their characteristics.
9. Complete a chart of carbon steel classifications, characteristics, and typical uses.
10. Match principal steel alloys with their uses.
11. Complete a chart of alloy steel classifications, characteristics, and typical uses.
12. Complete a chart of iron classifications, characteristics, and typical uses.
13. Complete statements about guidelines for identifying metals by color and characteristics.
14. Select true statements about aluminum, its characteristics, and uses.
15. Complete statements about basics of the commercial system for identifying aluminum.

16. Select true statements about the 1XXX group commercial identification system.

17. Select true statements about the 2XXX plus group commercial identification system.

18. Solve problems about other elements of commercial aluminum identification and their meanings.

19. Complete definitions of aluminum quality designations and their meanings.

20. Arrange in order the steps in using the commercial system to identify aluminum.

21. Match other nonferrous metals with their typical uses.

22. Select true statements about guidelines for testing properties of metals.

23. Select true statements about equipment requirements for spark testing.

24. Complete statements about guidelines for spark testing.

25. Complete statements about characteristics of residual stresses.

26. Select true statements about causes of residual stresses and distortion.

27. Select true statements about guidelines for changing the welding procedure to control stresses.

28. Identify routes for heat expansion in basic welds.

29. Identify results of longitudinal and transverse stress in basic welds.

30. Complete statements about heat applications and their uses in weld quality control.

31. Select true statements about guidelines for preheating in special conditions.

32. Complete statements about methods of preheating and postheating and their applications.

33. Match torch preheating techniques with their applications.

34. Match types of steels with their recommended preheat temperatures.

35. Match temperature-sensing devices with their uses.

36. Identify methods for controlling distortion with the welding process.

37. Select true statements about guidelines for controlling distortion with mechanical means.

38. Match methods for controlling distortion with restraining devices with their applications.

*39. Identify selected metals by appearance, color, and corrosion characteristics. (Assignment Sheet 1)

*40. Conduct magnet tests to identify common metals used for welding. (Job Sheet 1)

*41. Conduct chisel tests to identify common metals used for welding. (Job Sheet 2)

*42. Conduct spark tests to identify common metals used for welding. (Job Sheet 3)

*Assignment and Job Sheets are located in the Student Workbook.

Information Sheet

Objective 1

Terms and definitions

a. **AA**—Aluminum Association

b. **AISI**—American Iron and Steel Institute

c. **Compatibility**—Two or more metals that have similar properties that can readily be joined

d. **Extruding**—The process of forcing a metal through a special die to give it shape and length

e. **Filler metals**—Metals added in making a brazed, welded, or soldered joint

f. **Interpass temperature**—Maintenance of heat to a base metal and weld passes during a welding process

g. **Metallurgy**—The science that explains the properties, behavior, and internal structure of metals

h. **Postheating**—Application of heat to a weld and/or a base metal after a welding operation to promote a slower cooling rate and relieve stresses in the base metal and the weldment

i. **Preheating**—Application of heat to a base metal before welding or cutting

j. **SAE**—Society of Automotive Engineers

k. **Strain-hardened**—A metal that has had its strength, hardness, and brittleness increased with or without heating

l. **Weldment**—Assembly of two or more metal parts with welding

Objective 2

Advantages of proper metal identification

a. Proper metal identification helps determine the welding processes that are most effective and economical with a particular metal.

b. Proper metal identification helps establish requirements for preheating, interpass heating, and postheating.

c. Proper metal identification helps establish what metals are compatible so that proper filler metals can be selected.

Objective 3

Basic metals, alloys, and properties and their definitions

a. **Ferrous metals**—Metals that contain iron as the major element

Example: Low, mild, medium, and high-carbon steels, and cast iron

b. **Nonferrous metals**—Metals that contain no iron or an extremely small amount of iron

Example: Aluminum, copper, zinc, lead, tin, nickel, silver, titanium, and gold

c. **Alloy**—A single element dissolved together with a metal or metals in a solid solution

d. **Alloy steels**—Steels formed by adding one or more additional elements to give the steels special properties

Note: Alloys may be either ferrous or nonferrous, but alloy steels are always ferrous.

e. **Mechanical properties**—The measure of how materials behave under applied loads

f. **Physical properties**—Properties such as melting point or thermal conductivity which are affected when metals are subjected to heat

g. **Chemical properties**—Properties which involve corrosion, oxidation, and reduction

Objective 4

Metal identification tests and their characteristics

a. **Appearance**—Surface color reveals the presence of oxidation; when exposed to weather, some metals will rust, others tarnish, and others remain oxidation free.

b. **Chemical**—Certain chemicals or acids applied to metals cause different reactions in different metals.

Example: When applied to stainless steel, a weak solution of nitric acid or copper sulfate remains clear, but when applied to carbon steel, it darkens.

c. **Chisel**—When chipped with a chisel, certain metals produce a continuous chip, others break up into small particles, and others cannot be chipped.

Example: Low-carbon steel chips easily and leaves a continuous chip, but cast iron is difficult to chip and breaks up into small pieces.

d. **File**—Nonferrous metals are usually easy to file, but ferrous metals are difficult to file.

e. **Magnet**—A magnet sticks to ferrous metals, but it will not stick to nonferrous metals.

f. **Sound**—When struck with a hammer, most metals have a characteristic ring or lack of it.

Example: Steel has a higher-pitched ring than cast iron

g. **Spark**—Ferrous metals have definite spark patterns, but nonferrous metals have no spark pattern.

Objective 5

Mechanical properties of metals and their characteristics

a. **Brittleness**—The tendency of certain metals to break or fracture if bent or struck sharply

b. **Ductility**—The capacity of a metal to be permanently stretched without breaking

c. **Elasticity**—The capacity of a metal to return to its original size and shape when the force that changed it is removed

d. **Elastic limit**—The incapacity of a metal to return to its original size and shape when the force that changed it is removed

e. **Elongation**—The measure of ductility of material measured in a tension test

f. **Fatigue**—The tendency of some metals to break or fracture under a repeated or sustained load

g. **Hardness**—The capacity of metal to resist penetration, abrasion, and deformation

h. **Impact resistance**—The capacity of a metal to absorb without failure the impact of a load applied rapidly

i. **Malleability**—The capacity of a metal to be hammered or rolled into shape without breaking

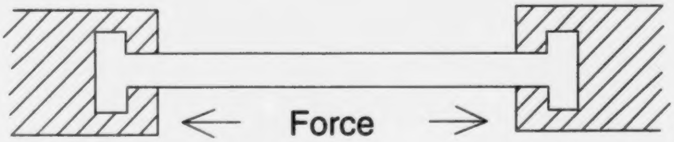
j. **Strength**—The capacity of a metal to resist changing its shape or size when exposed to external forces

Objective 6

Types of mechanical strengths and their characteristics

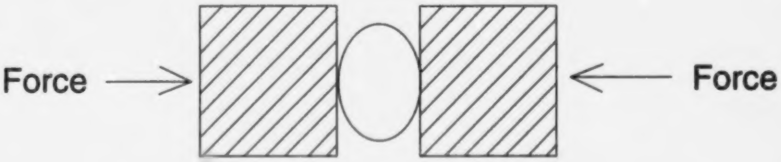
a. **Tensile strength**—The capacity of a metal to resist being pulled apart

Figure 1



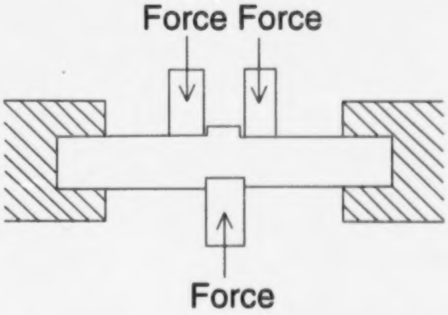
b. **Compressive strength**—The capacity of a metal to resist being pushed or crushed together

Figure 2



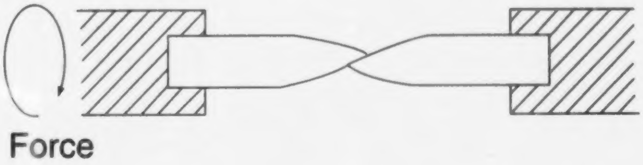
c. **Shear strength**—The capacity of a metal to withstand a sustained load across its cross section

Figure 3



d. **Torsional strength**—The capacity of a metal to resist twisting forces

Figure 4



Objective 7

Physical properties of metals and their characteristics

a. **Density** is the weight of a given piece of metal in relation to a unit size.

Example: A cubic foot of aluminum weighs less than a cubic foot of steel, so steel has a greater density than aluminum.

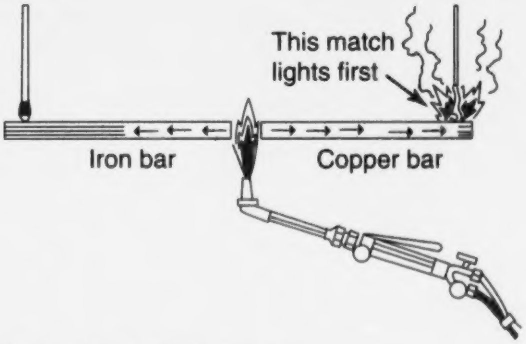
b. **Electrical conductivity** is the capacity of a metal to conduct electrical current.

Example: Copper has a much higher electrical conductivity than steel and is used in many electrical wires.

c. **Thermal conductivity** is the capacity of a metal to conduct heat.

Example: Silver and copper are metals that have high thermal conductivity.

Figure 5



Courtesy Lincoln Electric Company

d. **Thermal expansion** is the tendency of metals to expand when heated, as expressed in terms of coefficient of expansion.

Note: Thermal expansion is extremely important in welding because a metal such as aluminum which has a high coefficient of thermal conductivity will readily spread heat throughout the workpiece and minimize distortion at the weld zone, but metals such as stainless steel with a low coefficient of thermal conductivity will localize the heat in the weld zone and cause a greater amount of distortion.

e. **Melting point** is the point to which a metal must be heated before it will melt.

Objective 8

Steel identification systems and their characteristics

a. The SAE (Society of Automotive Engineers) and AISI (American Iron and Steel Institute) assign steel with a number system based on the principal alloying ingredients in the steel.

- 1 indicates carbon.
- 2 indicates nickel.
- 3 indicates nickel-chromium.

- 4 indicates molybdenum.
- 5 indicates chromium.
- 6 indicates chromium-vanadium.
- 7 indicates tungsten.
- 8 indicates nickel-chromium-molybdenum.
- 9 indicates silicon-manganese

b. The AISI (American Iron and Steel Institute) also identifies steel with a letter system to designate how the steel was produced.

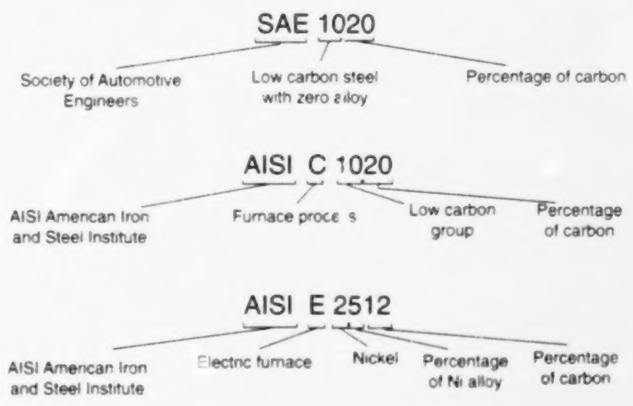
- A references open-hearth alloy steel.
- B references acid Bessemer carbon steel.
- C references basic open-hearth carbon steel.
- D references acid open-hearth steel.
- E references steel processed in an electric furnace.

c. SAE and AISI identification systems both give place values to four-digit number codes.

- The first digit indicates the type of alloy.
- The second digit indicates the percentage of the alloy designated in the first digit.
- The last two digits indicate the percentage of carbon in steel, in hundredths of 1 percent.

  Note: In the first example, the last two digits (20) indicate that the percentage of carbon in steel is 20/100 or 1/5 of 1%.

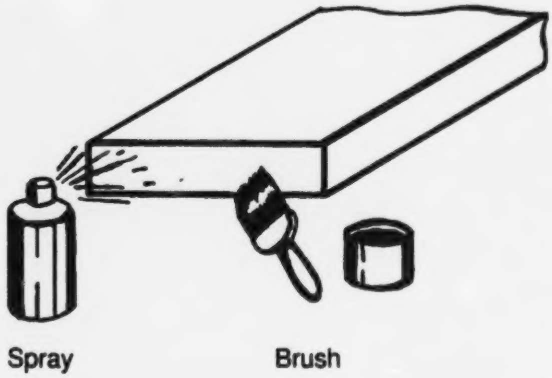
  Figure 6


SAE 1020
Society of Automotive Engineers
Low carbon steel with zero alloy
Percentage of carbon
AISI C 1020
AISI American Iron and Steel Institute
Furnace process
Low carbon group
Percentage of carbon
AISI E 2512
AISI American Iron and Steel Institute
Electric furnace
Nickel
Percentage of Ni alloy
Percentage of carbon

d. Color coding is a system that uses colors painted on the ends of steel bars or sheets to indicate the type of steel.

Note: Color coding varies with each manufacturer, so identification requires a guide from the mill that produced the steel; when working with color coded stock, start from the opposite end of the coloring so the stock can still be quickly identified even after part of it has been used.

Figure 7



e. UNS (Unified Numbering System) is a system that uses a five-digit number with a letter prefix that designates a general ferrous metal or alloy group.

Figure 8

ID Letter and Number	General Metal or Alloy Group
000001-D99999	General Metal or Alloy Group
F00001-F99999	Cast iron, carbon, and low-alloy steel castings
G00001-G99999	Carbon and alloy steels (AISI and SAE)
H00001-H99999	H steels (AISI)
K00001-K99999	Other steels and ferrous alloys
S00001-S99999	Stainless steels
T00001-T99999	Tool steels

Objective 9

Carbon steel classifications, characteristics, and typical uses

Figure 9

Classification	Characteristics	Typical Uses
Low carbon	0.07% to 0.15% carbon	Nails, iron bars and rods, auto bodies, and pipes
Mild steel	0.15% to 0.30% carbon	Gears, shafts, bolts metal frames, angles, and channels
Medium carbon	0.30% to 0.50% carbon	Axles, shafts, machine bolts, boilers, hammers, and sledges
High carbon	0.50% to 1.00% carbon	Screwdrivers, crow bars, axes, springs, razor blades, and fine cutters

Objective 10

Principal steel alloys and their uses

a. **Carbon**—Used to make steels hard and strong

Note: The largest tonnage of all steel produced is low, medium, or high-carbon steel, with low carbon steel the most produced of the three.

b. **Cobalt**—Used to make steels that will remain hard when subjected to very high temperatures

c. **Nickel**—Used to make special steels with improved ductility while maintaining strength and toughness and a high resistance to corrosion and shock

d. **Silicon**—Used to make special steels that are hard and brittle

e. **Molybdenum**—Produces the greatest hardening effect of any element except carbon

f. **Chromium**—Increases tensile strength and hardness, as well as resistance to corrosion and oxidation

Objective 11

Alloy steel classifications, characteristics, and typical uses

Figure 10

Classification	Characteristics	Typical Uses
Nickel steel	Strong and hard, resists corrosion, withstands shocks, vibration, and wear	Wire cables, railroad and car axles, and steel rails
Chromium steel	Fine grain, tough and strong, resists corrosion, shocks, and scratches	Auto bearings and safes
High chromium steel (Stainless steel)	Does not corrode, has a bright silvery finish that looks good	Sinks, tables, and food service items subject to high standards of cleanliness
Chrome-nickel steel	Hard and strong	Auto gears, springs, axles, and armor plate
Manganese steel	Tough and strong, can resist strain, shock, and hammering	Jaws of rock crushers, chains, gears, and safes
Molybdenum steel	Tough and strong, resists heat and impact wear	Auto parts, high-grade machinery, and roller bearings
Tungsten steel	Hard, fine grained, and resists heat	High-speed metal cutting tools
Tungsten steel (Magnet steel)	Holds magnetism well	Electrical measuring instruments
Tungsten steel (Tungsten carbide)	Hardest man-made metal	Cutting tools and dies
Vanadium steel	Tough, but lightweight, fine grained, and resists shock	Atuo axles, gears, and springs
Stellite steel	Extremely hard	Heavy cutting tools
High-speed steel	Self-hardening steel	Cutting tools, taps, and drills

Information Sheet

Objective 12

Iron classifications, characteristics, and typical uses

Figure 11

Classification	Characteristics	Typical Uses
Wrought iron	Resists corrosion, withstands shock, is malleable and easy to bend hot or cold	Rivets, bolts, nails, horseshoes, and ornamental iron
Gray cast iron	Relatively inexpensive, high compressive strength, but low tensile strength and brittle	Large pipes, stoves, water hydrants, and machinery frames
White cast iron	Very hard and brittle	Machine parts subjected to extreme wear or abrasion
Malleable cast iron	Tougher and more impact resistant than other cast irons	Farm tools, implement parts, and railroad equipment

Objective 13

Guidelines for identifying metals by color and characteristics

a. For low, medium, and high-carbon steels, look for new stock to be dark gray; these grades of steel rust with age, and rust rapidly when stored outside.

b. For manganese steels, look for a dull metallic surface on new stock; these steels rust with age, and rust rapidly when stored outside.

c. For stainless steels, look for bright, silvery-smooth surfaces; some grades of stainless rust with age and other grades tarnish.

d. For cast iron, look for a dull, gray color with evidence of the sand mold on new stock; cast irons rust rapidly in almost any environment.

e. For wrought iron, look for new stock to be light gray and smooth; wrought irons rust rapidly in almost any environment.

f. For aluminum, look for new stock to have a silvery-white, smooth surface; this light-weight metal has high corrosion resistance.

g. For copper, look for a reddish-brown, dull finish on new stock; copper resists corrosion, but it will tarnish.

h. For nickel, look for a hard, white finish; nickel resists rust and corrosion.

Objective 14

Aluminum, its characteristics and uses

a. Aluminum is most used and most abundant of the nonferrous metals.

b. Aluminum is a silvery-white metal with a brilliant surface beauty that resists corrosion and is maintenance free.

c. Pure aluminum is very soft and difficult to use, so it is usually combined with an alloy to change its characteristics.

d. Aluminum is a good conductor of electricity, an excellent thermal reflector when it is polished, and a good thermal conductor in other forms.

e. Aluminum is both malleable and ductile and can easily be formed into shapes or into wire.

f. Aluminum is available in sheets, plates, bars, wires, pipes, tubes, and a great number of extruded forms.

Objective 15

Basics of the commercial system for identifying aluminum

a. The commercial system identifies aluminum by groups:

  - The 1XXX group indicates aluminum of 99% or higher purity.
  - The 2XXX group indicates aluminum with copper as the principal alloying element.
  - The 3XXX group indicates aluminum with manganese as the principal alloying element.
  - The 4XXX group indicates aluminum with silicon as the principal alloying element.
  - The 5XXX group indicates aluminum with magnesium as the principal alloying element.
  - The 6XXX group indicates aluminum with silicon and magnesium in approximate proportions as the principal alloying element.
  - The 7XXX group indicates aluminum with zinc as the principal alloying element.

  Note: There are other aluminum identification systems, but the commercial system was developed by the Aluminum Association to reflect common product references used by consumers and producers.

b. In the commercial identification system, there is a four-digit ID system especially for group 1XXX, and another four-digit ID system for the 2XXX plus group.

Objective 16

Elements of the 1XXX group commercial identification system

a. In the 1XXX group four-digit code, the first digit indicates a minimum of 99% aluminum.

b. The second digit indicates the degree of special control of impurities, with 0 indicating no special control and 9 indicating the highest special control.

c. The last two digits indicate the percent of aluminum beyond 99%.

Example: In the code 1030, the first digit indicates aluminum of 99% minimum, the second digit indicates no special controls for impurities, and the last two digits indicate .30% aluminum beyond 99% or 99.30% aluminum. In the codes 1130, 1230, and 1330, the second digits show there has been a degree of control for impurities.

Objective 17

Elements of 2XXX plus group commercial identification system

a. In the 2XXX plus group four-digit code, the first digit indicates the major alloying element in the aluminum.

b. The second digit indicates the amount of modification to the alloy, with 0 indicating no modification and 9 indicating the highest modification.

c. The last two digits have no special significance, but serve only to identify the different alloys in the groups as they pertain to manufacturing.

Example: In the code 2017, the first digit indicates a copper alloy and the second digit indicates no modification to the alloy. The last two digits have significance only to the manufacturer. However, the second digit in the code 2317 indicates a modification was made to the copper alloy.

Objective 18

Other elements of commercial aluminum identification and their meanings

a. Commercial aluminum identification uses both letters and numbers to indicate temper designations, the method and degree of tempering during the manufacturing process.

b. The basic designations are:

- F means as fabricated with no special tempering.
- O means annealed to produce a soft temper.
- H means strain hardened to produce a stronger temper.

c. The H designation reflects the hardness of the temper on a scale of 1 through 9, working on a base 8 system.

Example: With the base 8, the number 2 indicates $^2/_8$ or $^1/_4$ hard, 4 indicates $^4/_8$ or $^1/_2$ hard, 6 indicates $^6/_8$ or $^3/_4$ hard, 8 indicates full hard, and 9 indicates extra hard.

d. In addition to the H designations for strain hardening, T designations are used to indicate product that has been thermally treated with or without strain hardening to produce stable tempers.

Note: There are 10 basic T designations ranging from 1 to indicate room temperature aging to 10 to indicate artificial aging and cold working. See Transparency 5 for details of the T designations.

Objective 19

Aluminum quality designations and their meanings

a. **AQ**—Aircraft quality

b. **CQ**—Commercial quality

c. **HTQ**—High-tensile quality

Objective 20

Steps in using the commercial system to identify aluminum

a. Determine the number code series.

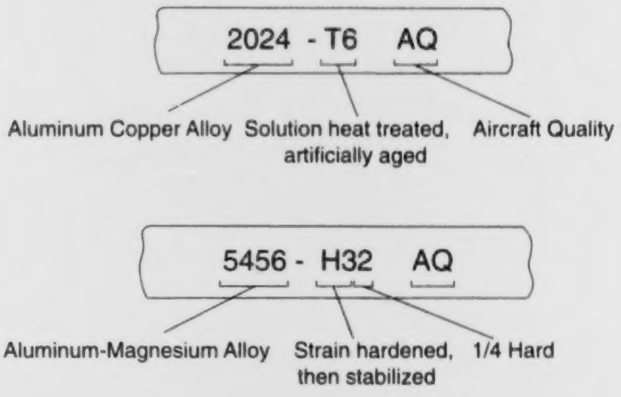
b. Determine the principal alloying element.

c. Determine the H or T designation.

d. Determine the degree of hardness.

e. Determine the quality designation.

Figure 12


2024 - T6 AQ
Aluminum Copper Alloy
Solution heat treated, artificially aged
Aircraft Quality
5456 - H32 AQ
Aluminum-Magnesium Alloy
Strain hardened, then stabilized
1/4 Hard

Objective 21

Other nonferrous metals and their typical uses

a. **Beryllium**—Used in the space program because of its light weight and high heat resistance

b. **Copper**—Used in electric and telephone wires and in industrial applications because it is the second best conductor of electricity; also alloyed with zinc or tin to make brass or bronze

c. **Gold**—Used for jewelry, coins, and coating electrical devices; usually alloyed with copper or nickel because it is too soft for general use

d. **Lead**—Used in auto batteries and alloyed with tin to make solder

e. **Magnesium**—Used in everything from lawn mower engine blocks to space vehicles because it is lightweight

f. **Nickel**—Used primarily as an alloy to toughen steel

g. **Tin**—Used for coating tin cans, and used as an alloy to make bronze, babbitt, pewter, and solder

h. **Titanium**—Used in supersonic aircraft because of its high heat resistance and capacity to withstand vibration; used in petrochemical applications because of its high corrosion resistance

i. **Silver**—Used in coins, jewelry, tableware, and in industrial applications because it is the best conductor of electricity

j. **Zinc**—Used to galvanize iron and steel for protection from rust

Objective 22

Guidelines for testing properties of metals

a. To test for hardness, use a Brinnell hardness tester or a Rockwell tester.

Figure 13—Rockwell tester

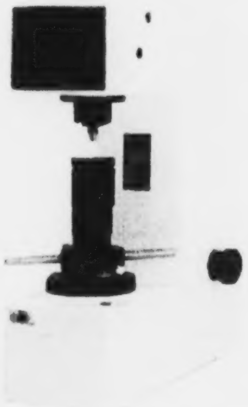


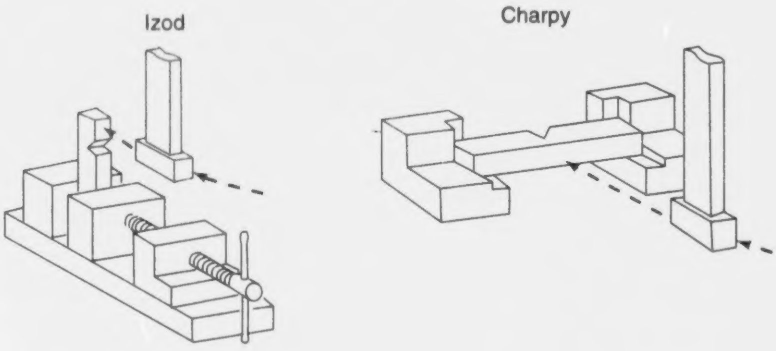
Figure 14—Brinnell tester

Note: The Brinell tester measures hardness by penetrating the metal with a hard sphere, and the Rockwell tester measures hardness by penetrating with a hard sphere or a sharp diamond point, depending on the hardness of metal.

b. To test for weld strength or ductility, use a hydraulic testing device that will have the power required to break or bend a welded sample.

c. To test for impact resistance, use an Izod or a Charpy test with the specimen properly secured for accepting the test load impact.

Figure 15



Izod

Charpy

Courtesy Lincoln Electric Company

d. To test for alloys by type and amount, use a spark test, and be sure the grinding wheel used in the test is free of residue.

Objective 23

Equipment requirements for spark testing

a. Spark testing requires a stationary or portable grinder with a medium-grit grinding wheel.

Note: 40 to 60 grit is the best range.

b. Spark testing requires the use of a grinding wheel with the speed of 5,000 surface feet per minute.

- Surface feet per minute equals the circumference of the grinding wheel in inches multiplied by the revolutions per minute (RPM) of the wheel or disc, divided by 12, (see Unit 6 to calculate circumference).

  Note: Check the manufacturer's literature to determine how RPM's change when using various diameters of grinding wheels or discs.

c. Use a clean grinding wheel for spark testing, and use a wire brush if the wheel needs cleaning.

Note: Do not use a regular aluminum oxide grinding wheel when grinding aluminum because the grinding wheel will "load up" and be almost impossible to clean. When testing aluminum, use only a silicon carbide grinding wheel or disc.

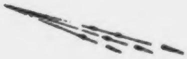
Objective 24

Guidelines for spark testing

a. Learn to recognize the types of sparks produced by the metals you grind.

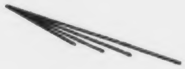
- An arrow looks like this:

  Figure 16



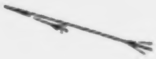
- A shaft looks like this:

  Figure 17



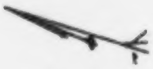
- A fork looks like this:

  Figure 18



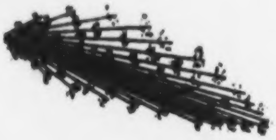
- A sprig looks like this:

  Figure 19



- A stream looks like this:

  Figure 20



b. Look for specific colors as sparks fly from the grinding wheel.

- A red color usually indicates cast iron.
- A straw yellow color at the end of a stream also indicates cast iron.
- A white color usually indicates low- or high-carbon steel.
- An orange color usually indicates chromium.

c. Evaluate the volume of sparks that fly from the grinding wheel.

- Nonferrous metals produce little or no sparks.
- Gray cast iron produces a small volume, and white cast iron produces a very small volume.
- Low-carbon steel produces a moderately large volume.
- High-carbon steel produces a large volume.
- Stainless steel produces a moderate to large volume, depending on the type and amount of alloy in the steel.

d. Note the distance the sparks fly from the grinding wheel.

- Low-carbon steels throw shafts about 70 inches long that terminate in forks.

  Note: Shafts become shorter and more numerous as carbon content increases.

- High-carbon steels throw numerous sprigs that look like sparklers about 55 inches long.
- Stainless and other alloy steels throw shafts and arrows at varying distances, depending on the amount of alloy.

Objective 25

Characteristics of residual stresses

a. Residual stresses are the undesirable elements of distortion left in a part or an assembly after a welding operation is completed.

b. The forces and counterforces of residual stress can produce shrinkage, fractures, and other forms of distortion that make parts difficult or impossible to fit up.

c. Residual stresses can produce in base metals, structural and metallurgical changes so severe that a welded assembly could fail in service and damage property or injure people.

Objective 26

Causes of residual stresses and distortion

a. In a welding process, filler metals and base metals expand uniformly in any direction if they are not restricted.

b. After a welding process, filler metals and base metals contract as they cool, and will assume their original shape if they are not restricted.

c. If restricted, filler metals and base metals cannot expand or contract uniformly.

d. Residual stresses will vary with joint design, the welding procedure, and metal type and thickness.

e. Welding thick metals promotes residual stresses, and the thicker the metal, the more problems with residual stresses.

Objective 27

Guidelines for changing the welding procedure to control stresses

a. Modify the joint design.

b. Minimize the heat input by modifying the welding process.

Example: Back step or intermittent welds

c. Select alternate filler metals or base metals.

d. Peen the weld lightly to help it stretch.

Note: Peen with care, because too much peening will add stresses or cause the weld to strain harden and become brittle.

e. Stress relieve by using a postweld heat treatment.

f. Add thermal control by using preheating, interpass heating, postheating, or all three.

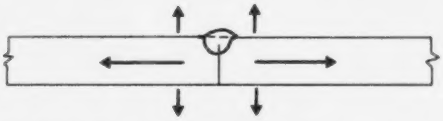
g. Add mechanical control by using clamps, wedges, or mechanical fixtures.

Objective 28

Routes for heat expansion in basic welds

a. In a normal butt weld, expansion occurs outward in all directions from the joint.

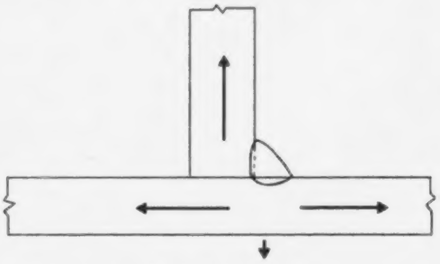
Figure 21



Courtesy Lincoln Electric Company

b. In a fillet weld, expansion also occurs outward in all directions.

Figure 22



Courtesy Lincoln Electric Company

Note: Heat applied to a weld causes metal to expand, so how expansion occurs in basic welds provides valuable clues for controlling residual stresses.

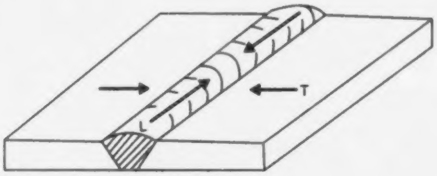
Objective 29

Results of longitudinal and transverse stress in basic welds

a. In a butt weld, the first passes can produce distortion **down** the length of the weld bead; this is called **longitudinal stress**.

b. In a butt weld, as the first passes solidify, the movement **across** the weld bead is restricted; this is called **transverse stress**.

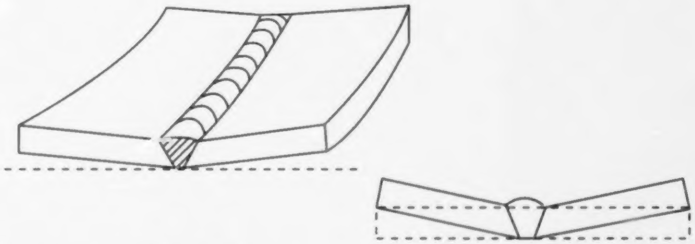
Figure 23



Courtesy Lincoln Electric Company

c. In a butt weld, the combination of longitudinal and transverse stresses results in distortion that usually causes the plates to rise from an even position to a slight angle.

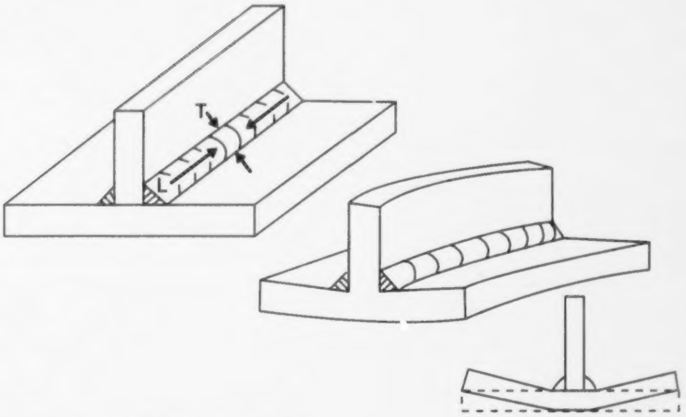
Figure 24



Courtesy Lincoln Electric Company

d. In a fillet weld, the combination of longitudinal and transverse stresses not only causes a change from flat to a slight angle, but the combination can result in a roll or twist along the length of the parts.

Figure 25



Courtesy Lincoln Electric Company

Objective 30

Heat applications and their uses in weld quality control

a. Preheating a part before a welding process starts can help control cracking, reduce stresses from shrinkage, and promote slower cooling to prevent excessive hardening and brittleness.

b. Heating between welding passes with interpass heat helps maintain the required temperature.

Note: Most welding processes provide sufficient interpass heat, but on large assemblies, heating between passes may be required.

c. Postheating after the welding process ends allows slow cooling which promotes stress relief in the weld and the base metal.

Objective 31

Guidelines for preheating in special conditions

a. Preheat when welding large or bulky parts or when welding parts with complicated shapes.

b. Preheat when atmospheric temperature is cold or when the temperature of the part is cold.

c. Preheat when the carbon or alloy content of steel is high.

d. Preheat when a fast welding speed is specified.

Note: Always refer to specifications before attempting to preheat any metal.

Objective 32

Methods of preheating and postheating and their applications

a. Preheat or postheat small parts in a furnace.

b. Preheat or postheat bulky parts by using acetylene, propane, or oil torches in banks of two or more.

c. Preheat or postheat long or wide parts with electrical strip heaters clamped parallel to joints, about 6" from the seam.

d. For general service preheating or postheating, use a natural gas torch with compressed air and a single-orifice heating tip.

e. When preheating or postheating with a torch, use a heating tip the same size as the tip required to oxyacetylene weld the joint.

f. For torch heating large parts, use a torch with a multiflame head or rosebud.

Note: Torch heating is used frequently in shop work because it is handy, but it also provides a hot flame that burns clean to help avoid contaminating the weld zone.

Objective 33

Torch preheating techniques and their applications

a. **Spot heating**—Applying heat at one specific point so that cooling will cause a slight inward movement around the joint and help control nondirectional distortion

b. **Slot heating**—Applying heat along a seam or perpendicular to a seam to control direction distortion

c. **Convex**—Applying heat along a side to shorten it, or applying other heating techniques to a certain side of a plate in order to flatten it

Information Sheet

Objective 34

Types of steels and their recommended preheat temperatures

a. **Mild steels**—Preheating is not normally required, but if temperature is below 50°F, preheat to about 100°F or higher, if the plate thickness is over 1".

b. **Medium-carbon steels**—Preheat from 200°F to 400°F, retain the same interpass temperature, and postheat is recommended, especially on thicker metals.

c. **High-carbon steels**—Preheat and interpass temperatures should be a minimum of 400°F, and postheat is recommended, especially on thicker metals.

Objective 35

Temperature-sensing devices and their uses

a. **Pyrometers**—Portable thermometers used to measure surface heat

b. **Thermocouples**—Temperature-sensing devices that may be attached to the work, but more often are used in heating ovens or postweld heat treatment processes

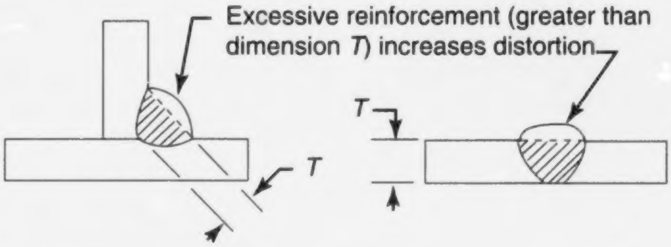
c. **Crayons and pellets**—Temperature-sensing devices available in different degrees; can be used to indicate a localized temperature; both crayons and pellets may be used in pairs to indicate a high and low temperature range

Objective 36

Methods for controlling distortion with the welding process

a. Do not overweld because excessive filler metal added to the joint increases shrinkage forces, but does not increase weld strength.

Figure 26

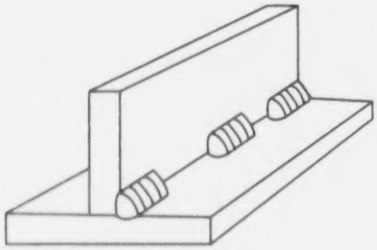


Excessive reinforcement (greater than dimension *T*) increases distortion

Courtesy Lincoln Electric Company

b. Use intermittent welds when you can because they provide strength, yet reduce the amount of heat and filler metal required.

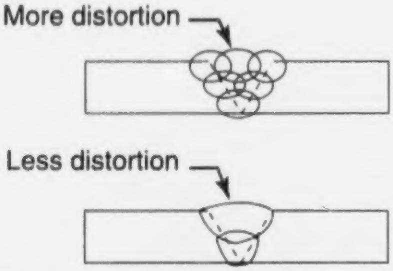
Figure 27



Courtesy Lincoln Electric Company

c. Use as few passes as specifications permit.

Figure 28

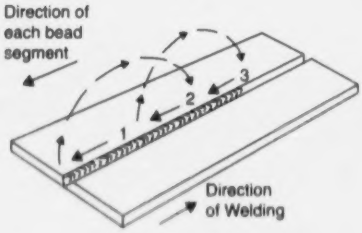

More distortion
Less distortion

Courtesy Lincoln Electric Company

d. Place welds at or along a neutral axis to lessen the leverage of forces that cause distortion.

e. Use backstep welding; welding usually proceeds left to right, but place beads right to left in order to spread heat uniformly to the outer edges and to bring plates back into alignment.

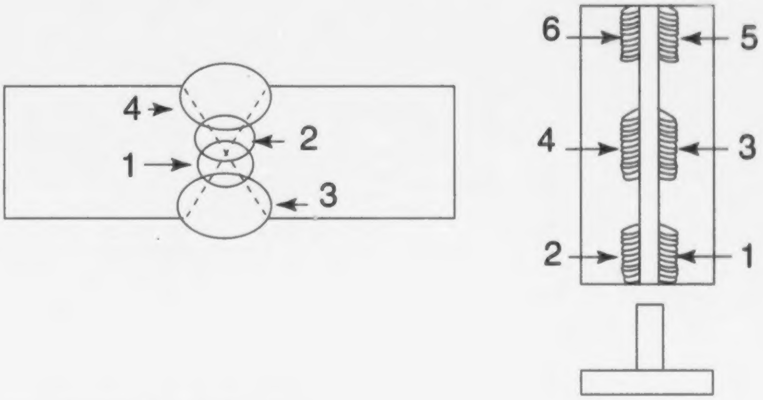
Figure 29


Direction of each bead segment
1
2
3
Direction of Welding

Courtesy Lincoln Electric Company

f. Weld in an alternating sequence; use intermittent welds alternately on fillet welds so that shrinkage in the second weld will counterbalance shrinkage in the first weld, and other alternate welds will counterbalance each other.

Figure 30


4
2
1
3
6
5
4
3
2
1

Courtesy Lincoln Electric Company

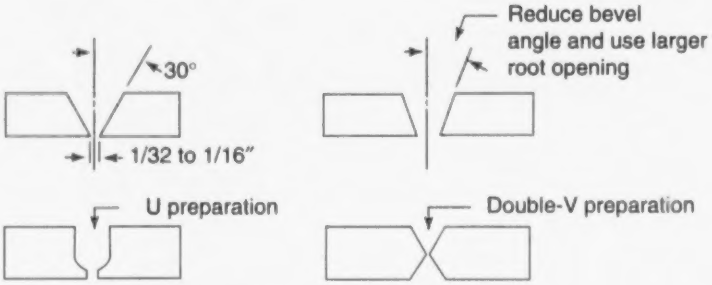
Objective 37

Guidelines for controlling distortion with mechanical means

a. Modify the edge preparation, especially on thicker metals; decrease the bevel angle and increase the root opening, or use a J- or U-joint design.

b. Use a double V-joint in place of a single V-joint because the double joint requires about half the weld metal for the same plate thickness.

Figure 31

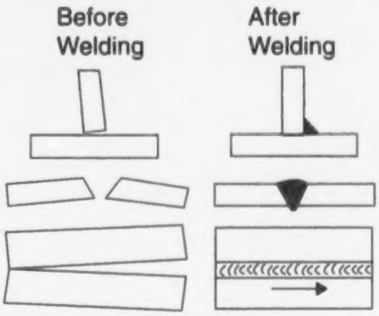

30°
1/32 to 1/16"
Reduce bevel angle and use larger root opening
U preparation
Double-V preparation

Courtesy Lincoln Electric Company

c. Anticipate the places and amount of shrinkage and preset parts so that shrinkage forces will pull them into alignment during welding.

Note: Presetting parts requires good estimating, but a few practice welds should demonstrate how it works.

Figure 32

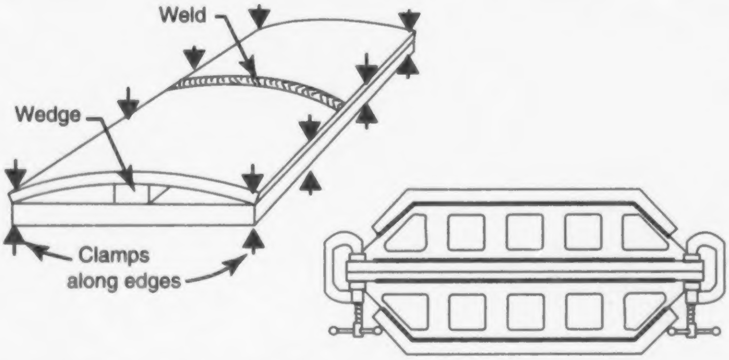


Courtesy Lincoln Electric Company

d. Prebend and clamp parts to make the joint longer so that shrinkage will cause the joint to lie flat as the plate cools and the clamps are removed.

e. Clamp parts front to back, if possible, to help distortion forces work against each other for shrinkage control.

Figure 33



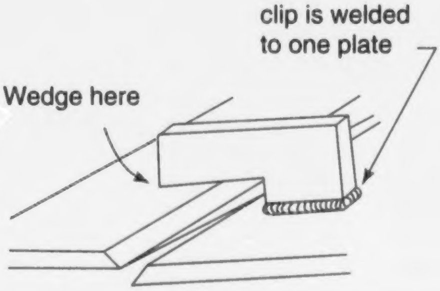
Courtesy Lincoln Electric Company

Objective 38

Methods for controlling distortion with restraining devices and their applications

a. When welding butt plates, tack weld clips along the edges of one plate, then drive wedges under the open side of the clips to force the edges into alignment.

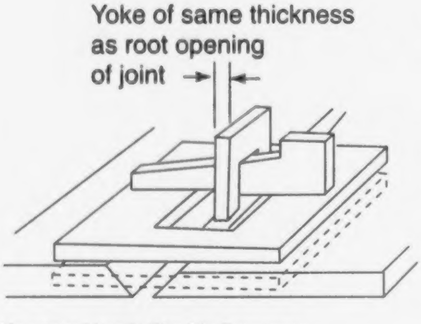
Figure 34


clip is welded
to one plate
Wedge here

Courtesy Lincoln Electric Company

b. For aligning plates, tack weld a yoke to a backup strip, slip the yoke between the edges, then place a yoke guide on top of the plates and drive a wedge through the first yoke to complete alignment.

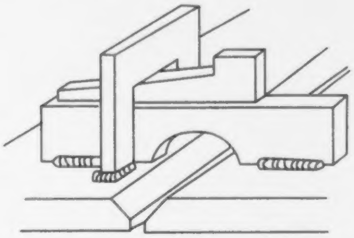
Figure 35


Yoke of same thickness
as root opening
of joint

Courtesy Lincoln Electric Company

c. For butt welds on thicker plates, tack weld a yoke on top of one plate, tack weld a bar to the top of the second plate, then drive a wedge between the yoke and the bar to complete alignment.

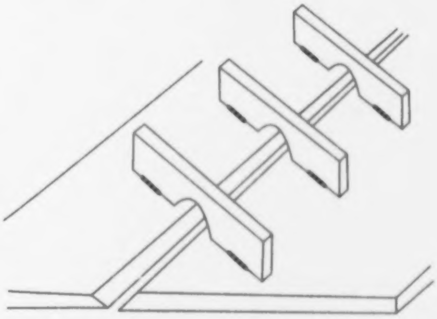
Figure 36



Courtesy Lincoln Electric Company

d. Several strongbacks together could restrain a weld so much that the weld could crack as it cools, so when several strongbacks are required, position them at a 45° angle across the joint to allow for transverse movement.

Figure 37



Courtesy Lincoln Electric Company

455

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1—Adjust a Bevel Square to a 45° Angle Using a Framing Square, a Combination Square, and a Protractor 99
2—Form 90° and 45° Angles with a Combination Square and Draw Parallel Lines on Metal Stock 103

*Assignment and Job Sheets are located in the Student Workbook.

Prerequisites:
None

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. Take Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet

☐ 3. **Study** Information Sheet, Objectives 1 and 2.

☐ 4. **Do** Assignment Sheet 1, "Add, Subtract, Multiply, and Divide Fractions."

☐ 5. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 6. If the evaluation is not satisfactory, repeat Steps 3 and 4.

☐ 6. **Do** Assignment Sheet 2, "Add, Subtract, Multiply, and Divide Decimal Equivalents."

☐ 7. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 8. If the evaluation is not satisfactory, repeat Steps 3 and 6.

☐ 8. **Study** Information Sheet, Objective 3.

☐ 9. **Do** Assignment Sheet 3, "Convert Fractions to Decimal Form, Change Fractions to a Common Denominator, and Reduce Fractions to Lowest Terms."

☐ 10. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 11. If the evaluation is not satisfactory, repeat Steps 8 and 9.

☐ 11. **Do** Assignment Sheet 4, "Write Fractions as Decimals and Percents."

Learning Activities Sheet

☐ 12. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 13. If the evaluation is not satisfactory, repeat Steps 8 and 11.

☐ 13. **Do** Assignment Sheet 5, "Write Percents as Fractions and Decimals."

☐ 14. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 15. If the evaluation is not satisfactory, repeat Steps 8 and 13.

☐ 15. **Study** Information Sheet, Objectives 4 and 5.

☐ 16. **Do** Assignment Sheet 6, "Write Decimals as Fractions and Percents."

☐ 17. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 18. If the evaluation is not satisfactory, repeat Steps 15 and 16.

☐ 18. **Do** Assignment Sheet 7, "Make Conversions with a Decimal Equivalent Chart."

☐ 19. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 20. If the evaluation is not satisfactory, repeat Steps 15 and 18.

☐ 20. **Do** Assignment Sheet 8, "Make Conversions with an Inches-to-Decimal Conversion Chart."

☐ 21. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 22. If the evaluation is not satisfactory, repeat Steps 15 and 20.

☐ 22. **Study** Information Sheet, Objectives 6 and 7.

☐ 23. **Do** Assignment Sheet 9, "Measure Distances with 1″, 1/2″, and 1/4″ Graduations."

☐ 24. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 25. If the evaluation is not satisfactory, repeat Steps 22 and 23.

☐ 25. **Do** Assignment Sheet 10, "Measure Distances with $^1/_4$" and $^1/_8$" Graduations."

☐ 26. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 27. If the evaluation is not satisfactory, repeat Steps 22 and 25.

☐ 27. **Do** Assignment Sheet 11, "Measure Distances with $^1/_8$" Graduations."

☐ 28. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 29. If the evaluation is not satisfactory, repeat Steps 22 and 27.

☐ 29. **Do** Assignment Sheet 12, "Measure Distances with $^1/_{16}$" Graduations."

☐ 30. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 31. If the evaluation is not satisfactory, repeat Steps 22 and 29.

☐ 31. **Do** Assignment Sheet 13, "Make Conversions with an English-Metric Conversion Chart."

☐ 32. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 33. If the evaluation is not satisfactory, repeat Steps 22 and 31.

☐ 33. **Research** Online resources to read about and practice fractions, decimals and percentages. Visit www.math.com as one of your resources.

☐ 34. **Study** Information Sheet, Objectives 8, 9, and 10.

☐ 35. **Do** Assignment Sheet 14, "Calculate Area of Geometric Figures."

Learning Activities Sheet

☐ 36. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 37. If the evaluation is not satisfactory, repeat Steps 34 and 35.

☐ 37. **Study** Information Sheet, Objectives 11 through 14.

☐ 38. **Do** Job Sheet 1, "Adjust a Bevel Square to a 45° Angle Using a Framing Square, a Combination Square, and a Protractor."

☐ 39. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 40. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 1 and repeat Steps 37 and 38.

☐ 40. **Do** Job Sheet 2, "Form 90° and 45° Angles with a Combination Square and Draw Parallel Lines on Metal Stock."

☐ 41. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 42. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 2 and repeat Steps 37 and 40.

☐ 42. **Check** With instructor for any additional assignments to be completed.

☐ 43. **Take** Posttest provided by instructor. After the test has been evaluated, follow instructor's recommendations.

☐ 44. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next Learning Activities Sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Objective Sheet

Unit Objective

After completing this unit, the student should be able to add, subtract, multiply, and divide fractions and decimal equivalents, convert fractions and decimals from one form to the other, identify graduations on rules, use an English-metric conversion chart, and form angles and lines with a bevel square. The student should demonstrate these competencies by completing the assignment and job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to basic math and measuring with their correct definitions.
2. Match basic mathematical terms with their definitions.
3. Complete statements about benefits of decimal equivalent charts.
4. Select true statements about benefits of an inches-to-decimal conversion chart.
5. Label place values in a decimal number.
6. Identify types of rules and list examples of their graduations.
7. Arrange in order the steps in reading a rule.
8. Match terms used in geometry with their definitions.
9. Match types of geometric figures with their descriptions.
10. Match units of measure with their equivalents.
11. Match squares, rectangles, and triangles with formulas for calculating their perimeters.
12. Calculate the area of geometric figures.
13. Solve problems about English-metric conversion charts and how to use them.
14. Solve problems about methods of sizing commonly used steel stock.

*15. Add, subtract, multiply, and divide fractions. (Assignment Sheet 1)

*16. Add, subtract, multiply, and divide decimal equivalents. (Assignment Sheet 2)

*17. Convert fractions to decimal form, change fractions to a common denominator, and reduce fractions to lowest terms. (Assignment Sheet 3)

*18. Write fractions as decimals and percents. (Assignment Sheet 4)

*19. Write percents as fractions and decimals. (Assignment Sheet 5)

*20. Write decimals as fractions and percents. (Assignment Sheet 6)

*21. Make conversions with a decimal equivalent chart. (Assignment Sheet 7)

*22. Make conversions with an inches-to-decimal conversion chart. (Assignment Sheet 8)

*23. Measure distances with 1″, $^1/_2$″, and, $^1/_4$″ graduations. (Assignment Sheet 9)

*24. Measure distances with $^1/_4$″ and $^1/_8$″ graduations. (Assignment Sheet 10)

*25. Measure distances with $^1/_8$″ graduations. (Assignment Sheet 11)

*26. Measure distances with $^1/_{16}$″ graduations. (Assignment Sheet 12)

*27. Make conversions with an English-metric conversion chart. (Assignment Sheet 13)

*28. Calculate area of geometric figures. (Assignment Sheet 14)

*29. Adjust a bevel square to a 45° angle using a framing square, a combination square, and a protractor. (Job Sheet 1)

*30. Form 90° and 45° angles with a combination square and draw parallel lines on metal stock. (Job Sheet 2)

*Assignment and Job Sheets are located in the Student Workbook.

Information Sheet

Objective 1

Terms and definitions

a. **A or a**—Area, the measurement of surface inside a figure

b. **B or b**—Base

c. **Cubic measure**—The measurement of volume

d. **English System**—A system of measurement based on feet and pounds

e. **Graduations**—Subdivisions on a measuring device

f. **H or h**—Height

g. **L or l**—Length

h. **Metric System**—A system of measurement based on meters and kilograms

i. **P or p**—Perimeter, the distance around a flat surface

j. **Pi or π**—A letter from the Greek alphabet used to indicate the ratio of the circumference of a circle to its diameter

Note: Pi is 3.14 or sometimes carried to 3.1416 or further for critical measurements.

k. **Square measure**—The measurement of area

l. **Sublinear numbers**—Numbers which appear below a line to clarify a reference

Examples: b_1 means base one, and L_2 means length two

m. **Superlinear numbers**—Numbers which appear above a line to indicate the degree of increase in power

Examples: R^2 means radius square and 10^3 means ten to the third power, 10 x 10 x 10 or 1,000

Objective 2

Basic mathematical terms and their definitions

a. **Whole number**—Any number or numbers used to indicate an entire unit, quantity, or amount

Examples: 1, 3, 10, 25

b. **Fraction**—Two numbers consisting of a numerator and denominator separated by a fraction line to indicate a part of one unit

Examples: $^{1}/_{8}$, $^{1}/_{4}$, $^{1}/_{2}$, $^{1}/_{16}$, $^{1}/_{32}$, $^{1}/_{64}$

c. **Mixed number**—Any whole number plus a fractional part of one additional unit

Examples: $1^{1}/_{8}$, $3^{1}/_{4}$, $5^{1}/_{2}$, $6^{3}/_{4}$

d. **Numerator**—The top number of a fraction

Example: The numerator of $^{1}/_{3}$ is 1

e. **Denominator**—The bottom number of a fraction

Example: Denominator of $^{3}/_{4}$ is 4

f. **Proper fraction**—A fraction whose numerator is less than the denominator, indicating a value of less than one unit

Examples: $^{5}/_{16}$, $^{3}/_{8}$, $^{7}/_{8}$, $^{9}/_{16}$

g. **Improper fraction**—A fraction whose numerator is equal to or greater than the denominator, indicating a value greater than one unit

Examples: $^{9}/_{8}$, $^{18}/_{16}$, $^{3}/_{2}$, $^{7}/_{4}$

h. **Unit fraction**—A proper fraction with a numerator of 1

Examples: $^{1}/_{3}$, $^{1}/_{4}$, $^{1}/_{2}$

i. **Complex fraction**—A fraction with either or both terms expressed as a fraction or mixed number

Examples: $\frac{7}{^{1}/_{16}}$ $\frac{5^{4}/_{2}}{2^{3}/_{4}}$

j. **Lowest terms**—The lowest base number (numerator and denominator) by which a fraction may be reduced for simplification in unit measurement

Example: $^{12}/_{16} = {}^{6}/_{8} = {}^{3}/_{4}$ which is the lowest term

k. **Common denominator**—Two fractions with the same denominator in each fraction (proper or improper) to permit simplification in adding and dividing fractions

Example: $^{1}/_{8} + {}^{1}/_{16} + {}^{1}/_{32} + {}^{1}/_{64} = {}^{8}/_{64} + {}^{4}/_{64} + {}^{2}/_{64} + {}^{1}/_{64} = {}^{15}/_{64}$

l. **Factors**—The parts of a number that can be multiplied to equal that number

Examples: 2 and 5 are factors of 10 because 2 x 5 = 10; 6 and 2 and 3 and 4 are factors of 12 because 6 x 2 = 12 and 3 x 4 = 12

m. **Sum**—The result of addition

Example: 4 is the sum of 2 + 2

n. **Quotient**—The result of division

Example: 2 is the quotient of 6 ÷ 3

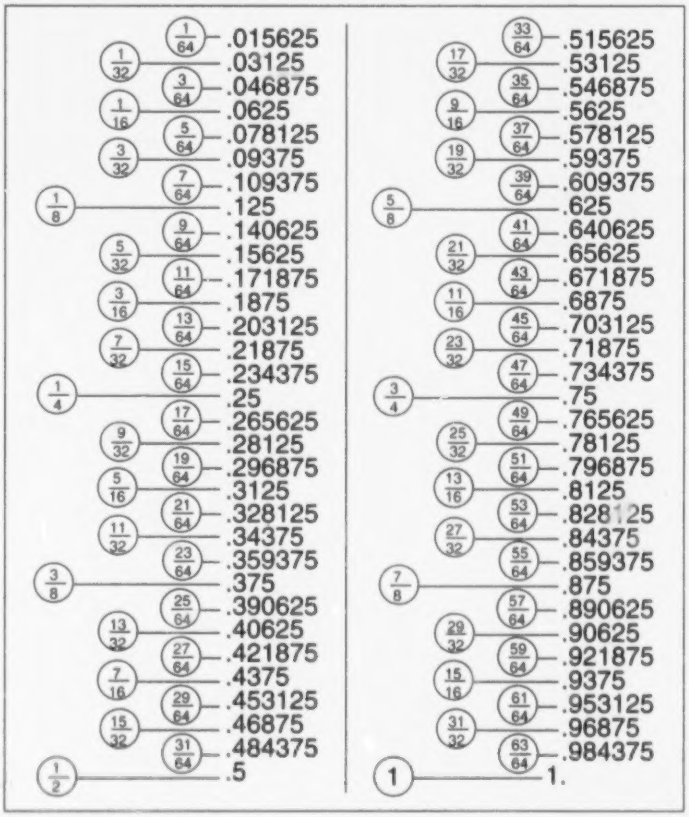
Objective 3

Benefits of decimal equivalent charts

a. Decimal equivalent charts provide a quick reference for converting fractions to decimals.

b. Converting fractions to decimals provides greater accuracy in measuring.

Figure 1



1/64	.015625	33/64	.515625
1/32	.03125	17/32	.53125
3/64	.046875	35/64	.546875
1/16	.0625	9/16	.5625
5/64	.078125	37/64	.578125
3/32	.09375	19/32	.59375
7/64	.109375	39/64	.609375
1/8	.125	5/8	.625
9/64	.140625	41/64	.640625
5/32	.15625	21/32	.65625
11/64	.171875	43/64	.671875
3/16	.1875	11/16	.6875
13/64	.203125	45/64	.703125
7/32	.21875	23/32	.71875
15/64	.234375	47/64	.734375
1/4	.25	3/4	.75
17/64	.265625	49/64	.765625
9/32	.28125	25/32	.78125
19/64	.296875	51/64	.796875
5/16	.3125	13/16	.8125
21/64	.328125	53/64	.828125
11/32	.34375	27/32	.84375
23/64	.359375	55/64	.859375
3/8	.375	7/8	.875
25/64	.390625	57/64	.890625
13/32	.40625	29/32	.90625
27/64	.421875	59/64	.921875
7/16	.4375	15/16	.9375
29/64	.453125	61/64	.953125
15/32	.46875	31/32	.96875
31/64	.484375	63/64	.984375
1/2	.5	1	1.

c. The decimal equivalent chart is also handy for converting decimals into fractions, if such information is required.

Objective 4

Benefits of inches-to-decimal conversion chart

a. Converting inches on a rule into decimal form is much faster when you use an inches-to-decimal chart.

b. An inches-to-decimal conversion chart provides an easy reference for adding, subtracting, multiplying, or dividing parts of a linear measurement.

Figure 2—Inches-to-Decimal Conversion Chart

Fractions of Inches		Inches	
1/16″	.0052	1″	.0833
3/32″	.0078	2″	.1667
1/8″	.0104	3″	.2500
5/32″	.0130	4″	.3333
3/16″	.0156	5″	.4167
7/32″	.0182	6″	.5000
1/4″	.0208	7″	.5833
9/32″	.0234	8″	.6667
5/16″	.0260	9″	.7500
3/8″	.0313	10″	.8333
7/16″	.0364	11″	.9167
1/2″	.0417	12″	1.0000
9/16″	.0468		
5/8″	.0521		
11/16″	.0572		
3/4″	.0625		
13/16″	.0677		
7/8″	.0726		
15/16″	.0781		

c. An inches-to-decimal conversion chart can also be used for finding feet and inches by simple addition.

Note: Do not confuse inches-to-decimal with decimal equivalents.

Objective 5

Place values of decimal equivalents and ways to express them

a. Decimal equivalents have place values related to their position in front of or beyond the decimal point.

Figure 3

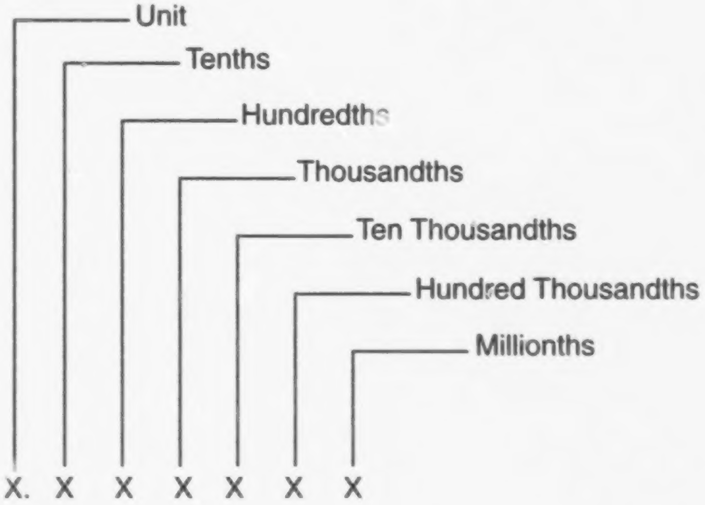
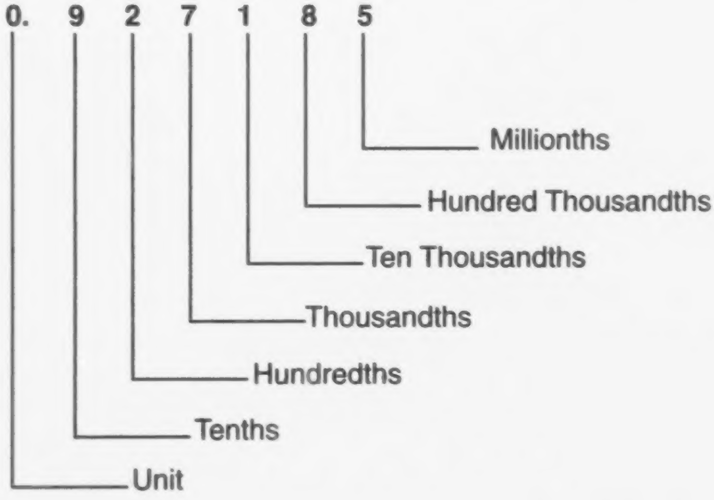

Unit
Tenths
Hundredths
Thousandths
Ten Thousandths
Hundred Thousandths
Millionths
X. X X X X X X

Figure 4


0. 9 2 7 1 8 5
Millionths
Hundred Thousandths
Ten Thousandths
Thousandths
Hundredths
Tenths
Unit

b. Decimal equivalents may be spoken or written as words.

Note: The number in Figure 4 is read as nine hundred twenty-seven thousandths, one hundred eight-five millionths.

c. Decimal equivalents may be written as numbers that combine numerators, denominators, whole numbers, mixed numbers, and other forms to express a value.

Example: $^{21}/_{64} = 0.3281$

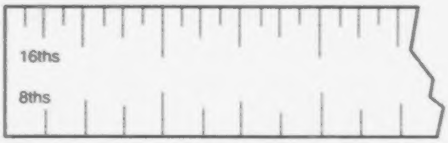
Objective 6

Types of rules and their graduations

a. Fractional:

- Eighths ($^{1}/_{8}$″)
- Sixteenths ($^{1}/_{16}$″)
- Thirty-seconds ($^{1}/_{32}$″)
- Sixty-fourths ($^{1}/_{64}$″)

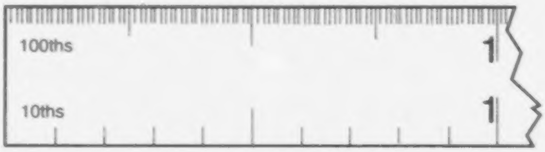
Figure 5



b. Decimal:

- Tenths (0.1)
- Hundredths (0.01)
- Thousandths (0.001)

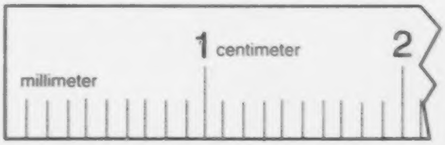
Figure 6



c. Metric:

- Meter (1.0m)
- Decimeter (0.1m)
- Centimeter (0.01m)
- Millimeter (0.001m)

Figure 7



Objective 7

Steps for reading a rule

a. Select proper scale.

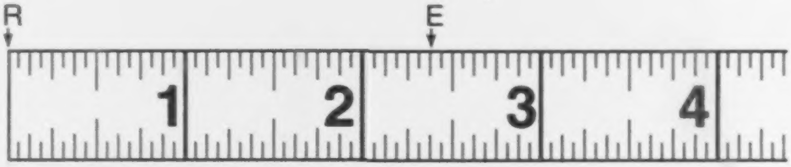
b. Count whole units.

c. Total the number of graduations.

d. Reduce graduations to lowest terms.

Example: When measuring the distance from R to E in the following illustration, the third mark past 2" indicates it is the $^{1}/_{8}$" scale, there are two whole units, two full inches preceding the fractional measure, and there are $^{6}/_{16}$ graduations following the whole units; $^{1}/_{2}$ should be reduced to the lowest terms, and the measurement from R to E is $2^{3}/_{8}$".

Figure 8



Objective 8

Terms used in geometry

a. **Geometric figure**—Shape formed by straight or curved lines

b. **Perimeter**—Outer limits or boundary

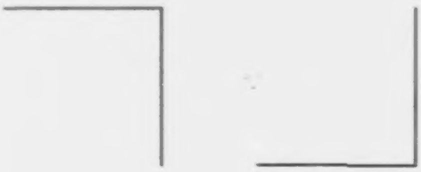
c. **Lineal**—Relating to, consisting of, or resembling a straight line

d. **Parallel**—Line or surface extending in the same direction an equal distance apart and never meeting

Example:

e. **Right angle**—Angle formed by two lines perpendicular to each other; a 90 degree angle

Example:

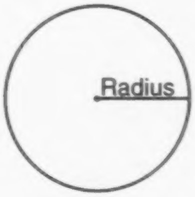


f. **Perpendicular**—Line or surface at right angle to another line or surface

Example:

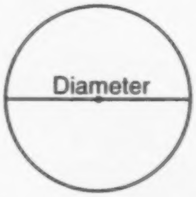
g. **Radius**—Line from the center of a circle to any point on the edge of the circle

Example:



h. **Diameter**—Distance between the outer edges of a circle through its center point

Example:



i. **Circumference**—Distance around the outer edge of a circle

j. **Pi**—Greek letter (π) representing the ratio of a circle's circumference to its diameter; ratio is approximately 3.1416

k. **Area**—Measure of a flat surface; expressed in square units

Example: W x L = Area is square units

l. **Volume**—Space occupied by a body; expressed in cubic units

m. **Cubic unit**—Unit with three equal dimensions including length, width, and height

n. **Cubic foot**—Volume of an object that is 1 foot long, 1 foot wide, and 1 foot high

Objective 9

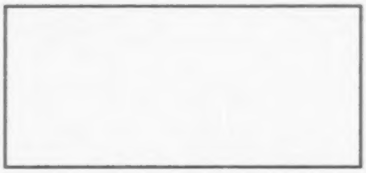
Types of geometric figures

a. **Square**—Figure having four sides of equal length and four right angles

Example:

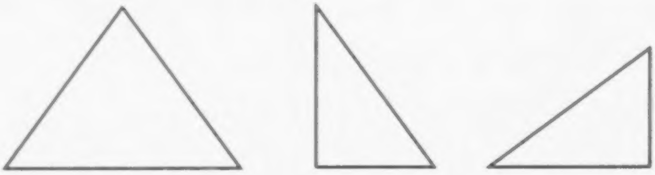
b. **Rectangle**—Figure with two parallel ends of equal length, two parallel sides of equal length, and four right angles

Example:



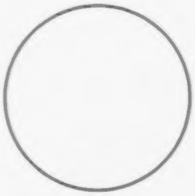
c. **Triangle**—Figure having three sides and three angles

Example:



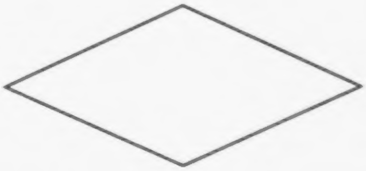
d. **Circle**—Flat, round figure formed by one curved line, all points of which are an equal distance from center point

Example:



e. **Rhombus**—Figure having no right angles and four sides of equal length

Example:

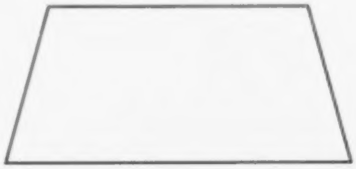


f. **Parallelogram**—Figure such as a square, rectangle, or rhombus with two parallel ends of equal length and two parallel sides of equal length

Example:

g. **Trapezoid**—Figure with only one pair of parallel opposite sides

Example:



Objective 10

Units of measure and their equivalents

a. **Inch (″)**—Equal to one-twelfth of a foot ($^1/_{12}$′) or one thirty-sixth of a yard ($^1/_{36}$ yard)

b. **Foot (′)**—Equal to twelve inches (12″) or one-third of a yard ($^1/_3$ yard)

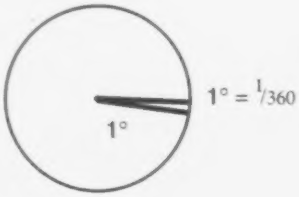
c. **Yard**—Equal to three feet (3′) or thirty-six inches (36″)

d. **Rod**—Equal to sixteen and one-half feet (16 $^1/_2$′)

e. **Mile**—Equal to five thousand, two hundred and eighty feet (5280′)

f. **Degree (°)**—Equal to $^1/_{360}$ of a circle

Example:



Objective 11

Squares, rectangles, and triangles and formulas for calculating their perimeters

a. **Square**—$P = 4s$

Example: The length of a side of a square is 6″

$P = 4s$
$P = 4 \times 6''$
$P = 24''$

b. **Rectangle**—$P = 2L + 2W$

Example: The length of a rectangle is 4′ and the width is 3′

$P = 2L + 2W$
$P = (2 \times 4') + (2 \times 3')$
$P = 8' + 6'$
$P = 14'$

c. **Triangle**—$P = s_1 + s_2 + s_3$

Example: A triangle has sides of 2′, 3′, and 8′

$P = s_1 + s_2 + s_3$
$P = 2' + 3' + 8'$
$P = 13'$

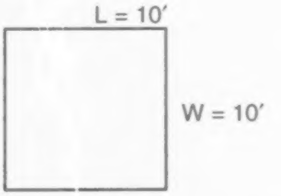
Objective 12

Calculating area of geometric figures

Note: Area is always labeled in square units of measure.

a. **Square**—Use the formula Area = Length x Width or A = LW.

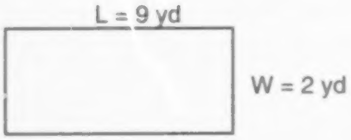
Example:



$A = LW$
$= 10 \times 10$
$= 100$ square feet

b. **Rectangle**—Use the formula Area = Length x Width or A = LW.

Example:

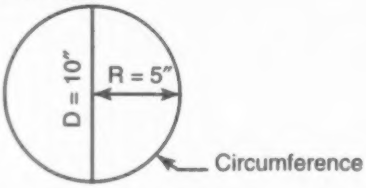


$A = LW$
$= 9 \times 2$
$= 18$ square yards

c. **Circle**—Use the formula Area = πr^2 (radius x radius).

Note: Pi (π) is 3.14, which is the circumference of a circle divided by the diameter of the circle.

Example:



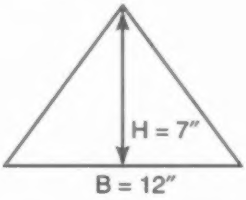
$$A = \pi r^2$$
$$= 3.14 \times (5 \times 5)$$
$$= 78.50 \text{ square inches}$$

Note: The circumference of a circle is calculated by multiplying the diameter of the circle by Pi (π); C = 3.14D

$$C = (\pi)D$$
$$= 3.14 \times 10''$$
$$= 31.4 \text{ inches}$$

d. **Triangle**—Use the formula Area = 1/2 Base x Height, or A = 1/2 BH.

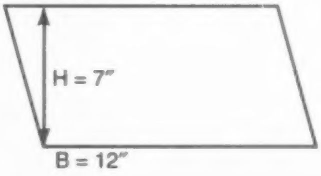
Example:



$$A = \frac{1}{2}BH$$
$$=(\frac{1}{2} \times 12) \times 7$$
$$= 6 \times 7$$
$$= 42 \text{ square inches}$$

e. **Parallelogram**—Use the formula Area = Base x Height, or A = BH.

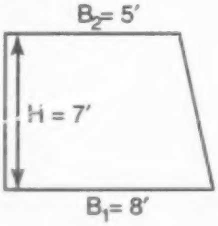
Example:



$$A = BH$$
$$= 12 \times 7$$
$$= 84 \text{ square inches}$$

f. **Trapezoid**—Use the formula Area = 1/2 $H(B_1 + B_2)$.

Example:



$$A = \frac{1}{2}H(B_1 + B_2)$$
$$= (\frac{1}{2} \times 7) \times (8 + 5)$$
$$= \frac{7}{2} \times 13$$
$$= \frac{7}{2} \times \frac{13}{1}$$
$$= \frac{91}{2}$$
$$= 45\frac{1}{2} \text{ square feet}$$

Objective 13

English-metric conversion charts and how to use them

Note: Because almost all overseas supplies used in American industry are measured on the metric system, the ability to convert metric to English measurement is becoming a common workplace requirement.

a. English-metric conversion charts provide a handy conversion factor for converting metrics to English and English to metrics.

b. To use an English-metric conversion chart, identify the English measurement, the metric form you want to convert it to, and then multiply the English measurement by the proper conversion factor.

Example: If you want to know what 10 inches would be in metrics, multiply 10 x 25.4 (the conversion factor) to get 254 millimeters.

c. To use an English-metric conversion chart, identify the metric measurement, the English form you want to convert it to, and then multiply the metric measurement by the proper conversion factor.

Example: If you want to know what 254 millimeters would be in English, multiply 254 x 0.04 to get 10 inches (the figure is actually 10.1, but it should be rounded off to 10).

	When You Know	You Can Convert To	When You Multiply By the Conversion Factor
LENGTH	Inches	Millimeters (mm)	25.4
	Millimeters	Inches	0.04
	Inches	Centimeters (cm)	2.54
	Centimeters	Inches	0.4
	Inches	Meters (m)	0.0254
	Meters	Inches	39.37
	Feet	Centimeters	30.5
	Centimeters	Feet	4.8
	Feet	Meters	0.305
	Meters	Feet	3.28
	Miles	Kilometers (km)	1.61
	Kilometer	Miles	0.62
AREA	Inches^2	Millimeters^2 (mm^2)	645.2
	Millimeters^2	Inches^2	0.0016
	Inches^2	Centimeters^2 (cm^2)	6.45
	Centimeters^2	Inches^2	0.16
	Foot^2	Meters^2 (m^2)	0.093
	Meters^2	Foot^2	10.76

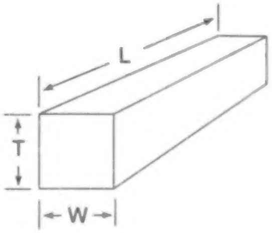
Information Sheet

Objective 14

Methods of sizing commonly used steel stock

a. Square bars are sized according to thickness, width, and length.

Example:

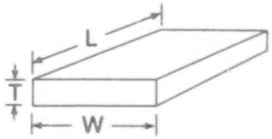


W = Width
T = Thickness
1/4" to 2-3/4", in graduations
of 1/16" and 1/8"
L = Length—16', 20', 36'

Courtesy Lincoln Electric Company

b. Hot and cold-rolled flat bars are sized according to thickness, width, and length.

Example:



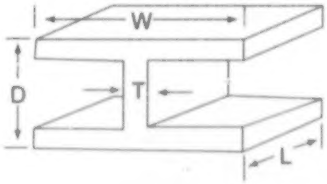
T= Thickness
1/4" to 1/2" in graduations of 1/16"
1/2" to 1-1/4" in graduations of 1/8"
1-1/4" to 2" in graduations of 1/4"
(3/16" and lighter, see Strips)
W=Width 3/8" to 6" in graduations of 1/8"
to 1/4"
L= Length 16', 36'

Courtesy Lincoln Electric Company

c. Structural W beams are sized according to depth, width of flange, web thickness, and length.

Note: Structural W beams are also called wide-flange beams to indicate that they are wide-flange beams, and the surfaces of the inside and outside flanges are parallel with each other.

Example:



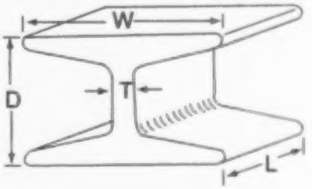
D= Depth (size)
4", 5", 6" and larger
W=Width of flange
T= Thickness of web
L= Length

Courtesy Lincoln Electric Company

d. Structural S beams are sized according to depth, width of flange, web thickness, and length.

Note: Structural S beams are also called standard beams or I beams, and are relatively easy to distinguish from wide-flange beams because the inside surface of the flange is sloped approximately 10 degrees.

Example:

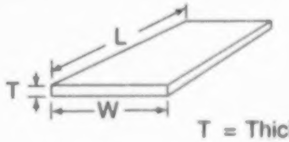


D = Depth (size)
3″, 4″, 5″, and larger
W = Width of flange
T = Thickness of web
L = Length

Courtesy Lincoln Electric Company

e. Hot rolled strips 3/16″ or less in thickness are sized according to thickness, width, and length.

Example:



T = Thickness—(thickness measurement expressed in fractions of an inch and gauge number).
3/16″ (.1875)
No. 10 (.134″); 1/8″ (.125″);
No. 12 (.109″); No. 14 (.083″);
No. 16 (.065″); No. 18 (.049″);
No. 20 (.035″); No. 22 (.028″);

W = Width
3/8″ to 2″ in graduations of 1/8″.
2″ to 3-1/2″ in graduations of 1/4″.
3-1/2″ to 6″ in graduations of 1/2″.
6″ to 12″ in graduations of 1″.

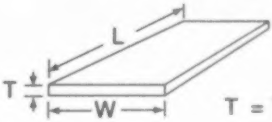
L = Length—14″ to 16″.

Courtesy Lincoln Electric Company

f. Hot and cold-rolled sheets are sized according to width and length with thickness indicated by F to indicate 3/16″ and less by gauge number.

Note: Rolled steel 3/16″ or less is classified as sheet, and over 3/16″ is classified as plate.

Example:



T = Thickness—(thickness measurement expressed in fractions of an inch and gauge number).
No. 8 (.1644″); No. 10 (.1345″);
No. 11 (.1196″); No. 12 (.1046″);
No. 14 (.0747″); No. 16 (.0598″);
No. 18 (.0478″); No. 20 (.0359″);
No. 22 (.0299″); No. 24 (.0239″);
No. 26 (.0179″); No. 28 (0.149″);

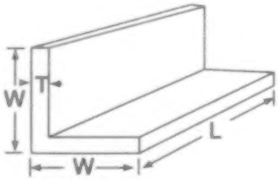
W = Width—measurements given in inches—
30″, 36″, 42″, 48″, 54″, 60″, 72″, 84″.

L = Length—measurements given in inches—
96″, 120″, 144″, 156″, 240″.

Courtesy Lincoln Electric Company

g. Bar and structural angles are sized according to width times width (both angles) times thickness and length.

Example:



W = Width of legs
1/2″ to 1-1/2″ in graduations of 1/8″ of flange.
3″ and over structural steel.

T = Thickness of leg 1/8″ to 1/2″ in graduations of 1/16″.

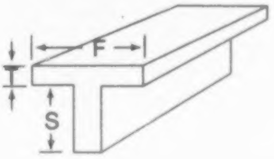
Angle stock is manufactured in equal or unequal width of legs, Example: 2-1/2″ x 1-1/2″ or 2″ x 2″.

L = Length—16′, 18′, 20′.

Courtesy Lincoln Electric Company

h. Bar and structural tees are sized according to flange width, stem width, thickness, and length.

Example:



F = Flange width
3/4" to 2-1/2" in graduations of 1/4".

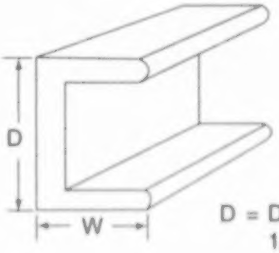
S = Stem width
3/4" to 2-1/2" in graduations of 1/4".

T = Thickness
1/8" to 3/8" in graduations of 1/16".

Courtesy Lincoln Electric Company

i. Bar size channels are sized according to depth, width of flange, thickness of web, and length.

Example:



D = Depth
1/2" to 3/4" in graduations of 1/16".
3/8" to 1-1/4" in graduations of 1/8".
1-1/4" to 2" in graduations of 1/4".

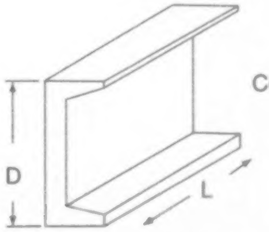
W = Width (of flange)—
1/4", 5/16", 3/8", 7/16", 1/2", 9/16", 3/4", 1".

T = Thickness of web—1/8", 3/16", 1/4".

Courtesy Lincoln Electric Company

j. Structural channels are sized according to depth of channel and length; common sizes are 3", 4", 5", 6", 7", and 8"

Example:

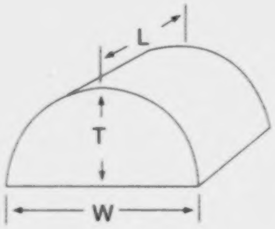


Common sizes are 3", 4", 5", 6", 7", and 8".

Courtesy Lincoln Electric Company

k. Hot-rolled half ovals are sized according to thickness, width, and length; half ovals come in 16' lengths.

Example:



T = Thickness
3/8″ to 1/2″ in graduations of 1/6″.

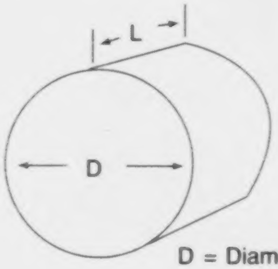
W = Width
1/8″ to 1-1/4″ in graduations of 1/8″.
1-1/4″ to 2″ in graduations of 1/4″.
2″ to 3″ in graduations of 1/2″.

L = Length—16′

Courtesy Lincoln Electric Company

l. Hot and cold-rolled rounds are sized according to diameter and length.

Example:



D = Diameter 3/8″ to 2″ or larger in graduation increases of 1/16″ and 1/8″.

L = Length—16′, 18′, and 20′.

Courtesy Lincoln Electric Company

Unit Contents

Student Components

Student Page

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2—Construct a Front View 111
3—Construct a Right Side View 113
4—Construct Missing Hidden Lines 115
5—Interpret Tolerance Dimensions in Decimals, Fractions, and Degrees 117
6—Construct Missing Visible and Hidden Lines 121
7—Make a Three-View Sketch 123
8—Construct Adjacent Parts in an Assembly Section 125

*Assignment Sheets are located in the Student Workbook.

Prerequisites:
None

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Read** Student Supplement 1, "Common Abbreviations and Their Meanings."

☐ 4. **Study** Information Sheet, Objectives 1, 2, and 3.

☐ 5. **Read** Student Supplement 2, "Orthographic Projection."

☐ 6. **Do** Assignment Sheet 1, "Construct a Top View."

☐ 7. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 8. If the evaluation is not satisfactory, repeat Steps 4 and 6.

☐ 8. **Do** Assignment Sheet 2, "Construct a Front View."

☐ 9. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 10. If the evaluation is not satisfactory, repeat Steps 4 and 8.

☐ 10. **Do** Assignment Sheet 3, "Construct a Right Side View."

☐ 11. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 12. If the evaluation is not satisfactory, repeat Steps 4 and 10.

☐ 12. **Do** Assignment Sheet 4, "Construct Missing Hidden Lines."

☐ 13. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 14. If the evaluation is not satisfactory, repeat Steps 4 and 12.

☐ 14. **Study** Information Sheet, Objectives 4, 5, and 6.

☐ 15.	**Do**	Assignment Sheet 5, "Interpret Tolerance Dimensions in Decimals, Fractions, and Degrees."
☐ 16.	**Stop**	Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 17. If the evaluation is not satisfactory, repeat Steps 14 and 15.
☐ 17.	**Study**	Information Sheet, Objectives 7 through 12.
☐ 18.	**Do**	Assignment Sheet 6, "Construct Missing Visible and Hidden Lines."
☐ 19.	**Stop**	Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 20. If the evaluation is not satisfactory, repeat Steps 17 and 18.
☐ 20.	**Do**	Assignment Sheet 7, "Make a Three-View Sketch."
☐ 21.	**Stop**	Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 22. If the evaluation is not satisfactory, repeat Steps 17 and 20.
☐ 22.	**Study**	Information Sheet, Objective 13.
☐ 23.	**Do**	Assignment Sheet 8, "Construct Adjacent Parts in an Assembly Section."
☐ 24.	**Stop**	Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 25. If the evaluation is not satisfactory, repeat Steps 22 and 23.
☐ 25.	**Study**	Information Sheet, Objectives 14, 15, and 16.
☐ 26.	**Check**	With instructor for any additional assignments to be completed.
☐ 27.	**Take**	Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.
☐ 28.	**Stop**	Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Objective Sheet

Unit Objective

After completing this unit, the student should be able to read, interpret, and construct top, side, and front views of objects, and interpret tolerance dimensions in decimals, fractions, and degrees. The student should demonstrate these competencies by completing the assignment sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to welding print reading with their correct definitions.
2. Match basic lines with their uses.
3. Identify basic views.
4. Differentiate between isometric and oblique drawings.
5. Solve problems related to dimensioning.
6. Solve problems related to tolerancing.
7. Differentiate between methods of dimensioning.
8. Select true statements about bevels and chamfers.
9. Complete statements about reduction and enlargement scales.
10. Identify types of holes.
11. Differentiate between types of threads.
12. Identify types of section views.
13. Complete statements about other symbols.
14. Complete statements about structural shapes.
15. Select true statements about requirements for a formal bill of material.
16. Complete statements about requirements for an informal bill of material.

*17. Construct a top view. (Assignment Sheet 1)

*18. Construct a front view. (Assignment Sheet 2)

*19. Construct a right side view. (Assignment Sheet 3)

*20. Construct missing hidden lines. (Assignment Sheet 4)

Objective Sheet

*21. Interpret tolerance dimensions in decimals, fractions, and degrees. (Assignment Sheet 5)

*22. Construct missing visible and hidden lines. (Assignment Sheet 6)

*23. Make a three-view sketch. (Assignment Sheet 7)

*24. Construct adjacent parts in an assembly section. (Assignment Sheet 8)

*Assignment Sheets are located in the Student Workbook.

Information Sheet

Objective 1

Terms and definitions

a. **Welding print**—A copy of an original drawing that uses lines, symbols, and other pictorial elements to show how a part or assembly should be made

b. **Working drawing**—An adaption of a print in total or in part to detail fabrication requirements of specific components in a production or job shop environment

c. **Notes**—Information in capital letters or numbers concerning details of construction

d. **Specifications**—A listing of specific materials, welding process, electrode, rod, or other specific requirements

e. **Symbol**—A pictorial view of a standard shape, line, material, or other items of information

f. **Basic lines**—A set of lines, arrows, and dashes used to represent size, shape, location, or composition of an object

g. **Dimensions**—Numbers used to define size and location

h. **Basic views**—A pictorial or orthographic projection of an object that displays its complex size and shape from all necessary sides

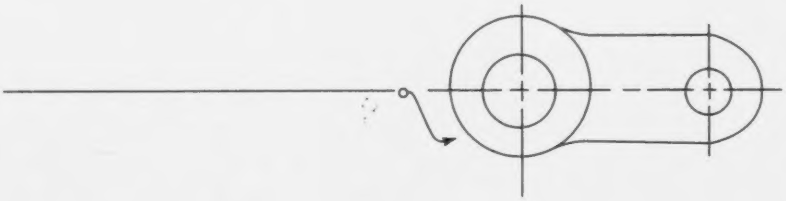
i. **Tolerance**—The total amount by which a specific dimension is permitted to vary in maximum and minimum limits usually expressed as a plus or minus value

Objective 2

Basic lines and their uses

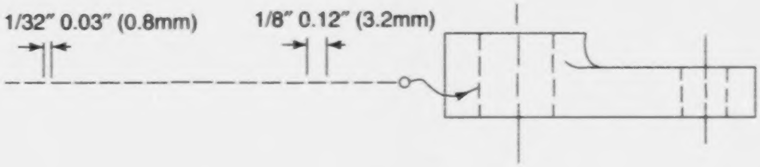
a. **Object or visible lines**—Thick, unbroken lines used to indicate the visible shape of an object

Figure 1



b. **Hidden lines**—Medium thickness lines of short dashes used to indicate interior details of objects that are not visible

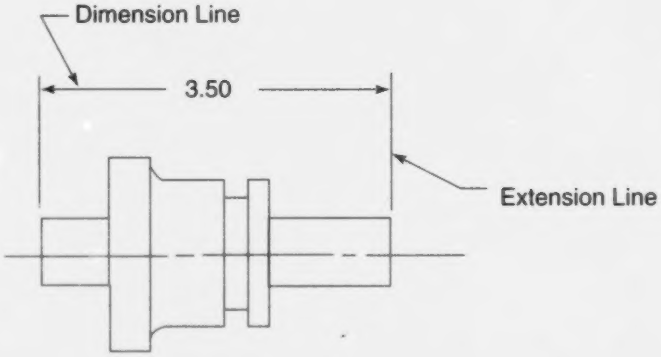
Figure 2


1/32″ 0.03″ (0.8mm)
1/8″ 0.12″ (3.2mm)

c. **Dimension lines**—Thin lines that have dimensions inserted at the center and are terminated by arrows at each end (see following graphic)

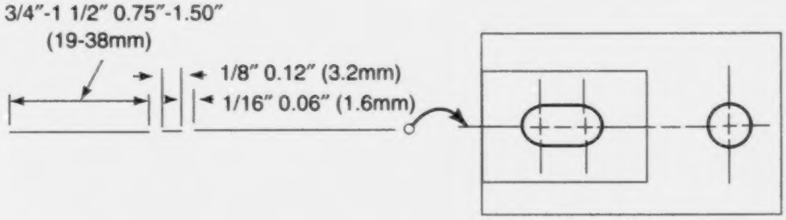
d. **Extension lines**—Thin lines used for placing limits on dimensions, they do not touch, but extend from the height, width, and length of an object (see following graphic)

Figure 3


Dimension Line
3.50
Extension Line

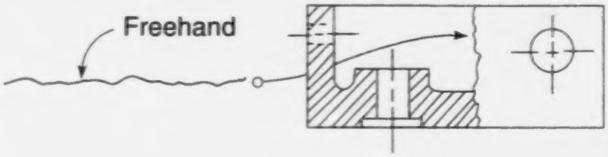
e. **Center lines**—Thin lines with alternating long and short dashes used to indicate the center of objects, holes, arcs, symmetrical shapes, and also used for extension lines for dimensioning

Figure 4


3/4″-1 1/2″ 0.75″-1.50″
(19-38mm)
1/8″ 0.12″ (3.2mm)
1/16″ 0.06″ (1.6mm)

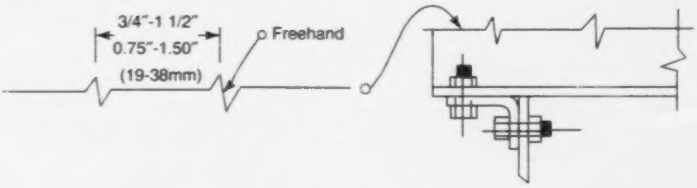
f. **Short break lines**—Thick, wavy lines used to indicate that an object has been slightly shortened to conserve space but still provide clarity

Figure 5



g. **Long break lines**—Thin lines with spur-shaped variations above and below the line to indicate that an object has been greatly shortened to conserve space

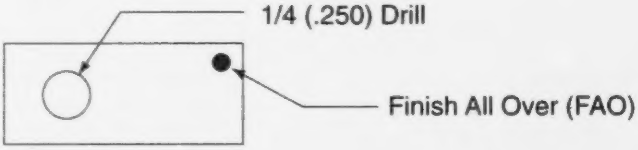
Figure 6



Note: Both long and short break lines are at points where shapes or features do not change.

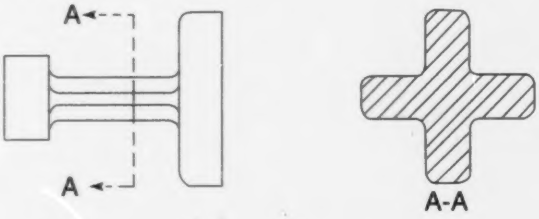
h. **Leader lines**—Fine, straight lines with an arrow or a dot at one end which points directly to a surface area or specific point for the purpose of dimensioning or adding a note

Figure 7



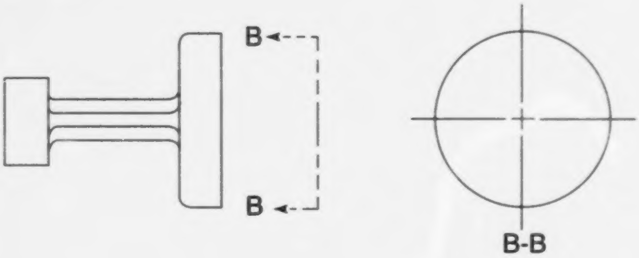
i. **Cutting plane lines**—Thick, broken lines of two short and one long sections used to indicate an imaginary cut through an object, with arrowheads terminating at right angles to the line to indicate direction in which the cut area should be viewed

Figure 8



j. **Viewing plane lines**—Lines that look like cutting plane lines, but instead of cutting through a shape, they are used to indicate that the surface should be viewed in the direction of the arrow heads

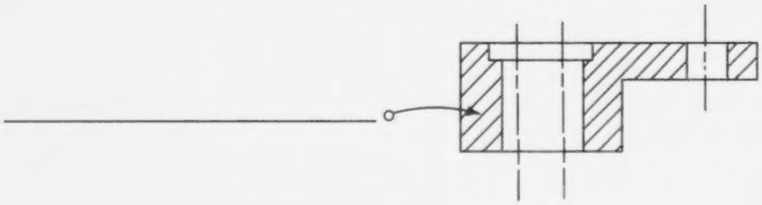
Figure 9



k. **Section lines**—Series of fine lines used to indicate the area of an imaginary cut made by a cutting plane line, and are normally identified by letters that reference the cutting plane letters

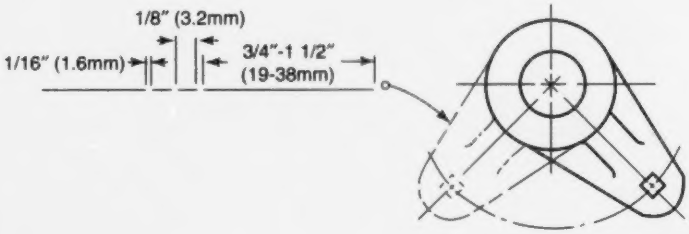
Note: Section lines are also used to denote material composition when different materials are used in manufacturing.

Figure 10



l. **Phantom lines**—Thin lines with alternating long and short dashes to indicate other positions to which a part or an object can be moved

Figure 11

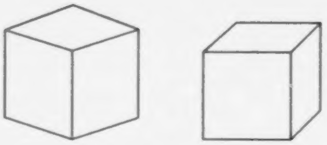


Objective 3

Basic views

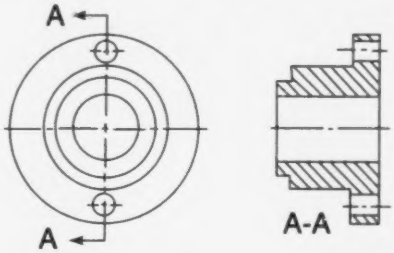
a. **Pictorial view**—Presents an object from a given angle as it appears visually, and helps a person form a better idea of an object's size, shape, and features

Figure 12



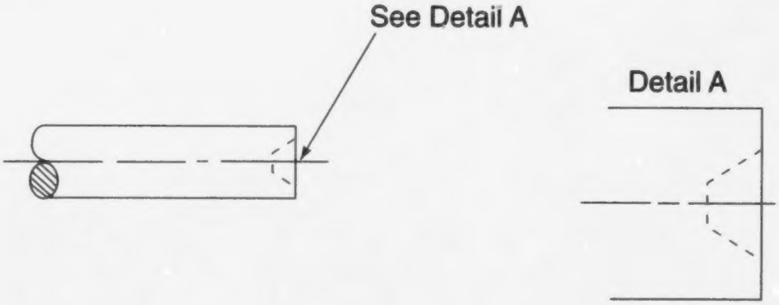
b. **Section view**—Presents an internal view of a specific section of a part so that shape, material, and other elements will be easier to visualize

Figure 13



c. **Detail view**—Presents an enlarged view of a specific portion of a part so that small details or features can be better visualized

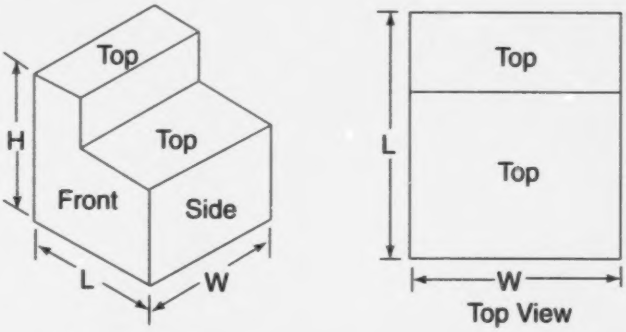
Figure 14



d. **Orthographic projection views**

- Top view—Presents a view that looks down on an object and provides definition of length and width, but does not show height

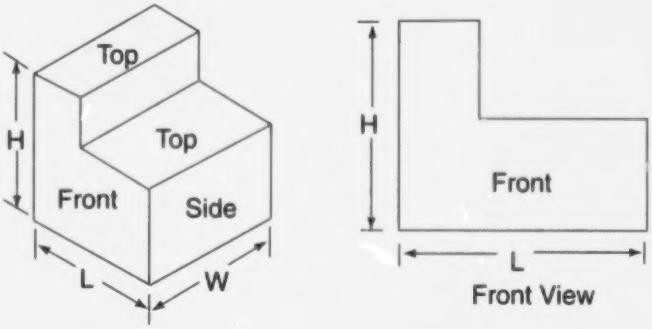
Figure 15


Top
Top
H
Front
Side
L
W
Top
Top
L
W

Top View

- Front view—Presents a view that shows the best shape of the object, but it does not necessarily represent the front of the object

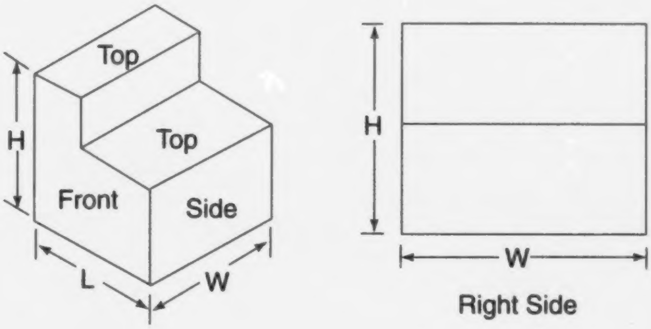
Figure 16


Top
Top
H
Front
Side
L
W
H
Front
L

Front View

- Side view—Presents a view of an object from the left or right side and provides details that are not shown in other views

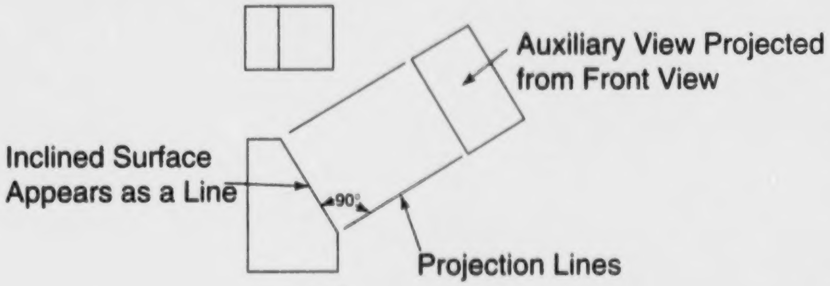
Figure 17


Top
Top
H
Front
Side
L
W
H
W

Right Side

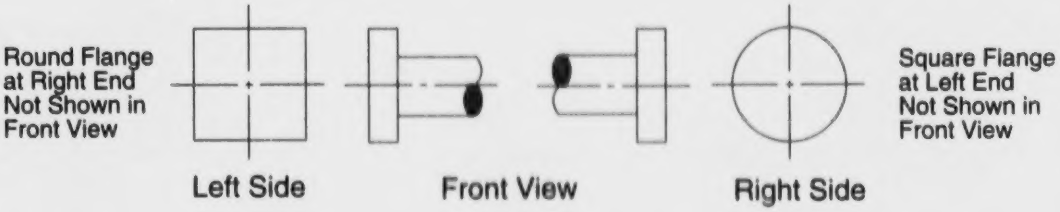
- Auxiliary view—Presents a view projected from any view of a slanted surface to show true shape and size

Figure 18


Auxiliary View Projected from Front View
Inclined Surface Appears as a Line
90°
Projection Lines

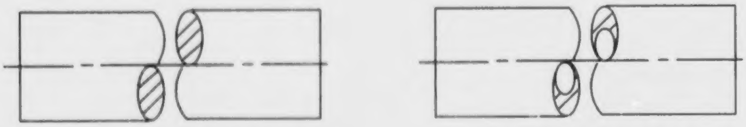
- Partial view—Shows a difference in portions of an object when like front views are shown, but actually differs when side views are drawn

Figure 19


Round Flange at Right End Not Shown in Front View
Square Flange at Left End Not Shown in Front View
Left Side
Front View
Right Side

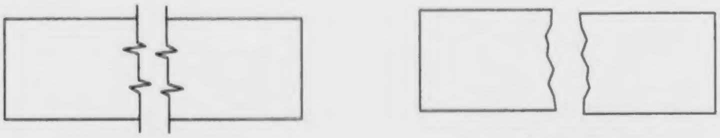
e. **Views with conventional breaks**—Used when an object has a uniform shape, but must be reduced to conform to space limitations

Figure 20



Round Solid Section

Pipe or Tubing



Long Break

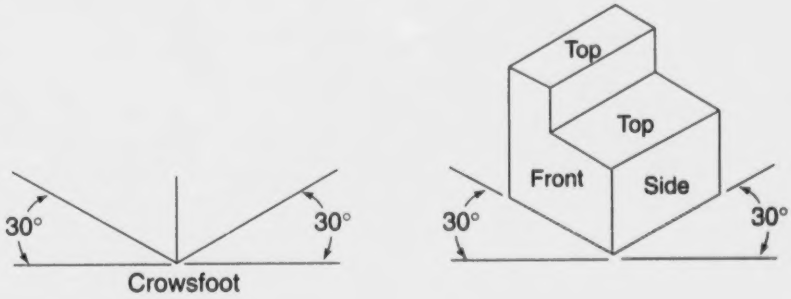
Short Break

Objective 4

Isometric and oblique drawings

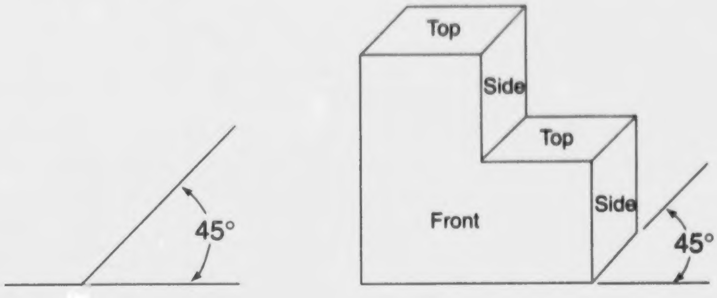
a. **Isometric**—A drawing that has all its surfaces projected at 30 degree angles from a basic starting point that is called a crowsfoot

Figure 21


30°
30°
Crowsfoot
Top
Top
Front
Side
30°
30°

b. **Oblique**—A drawing that has its lines parallel to each other at 45 degree angles to the right or left, and normally drawn from the front or side view

Figure 22

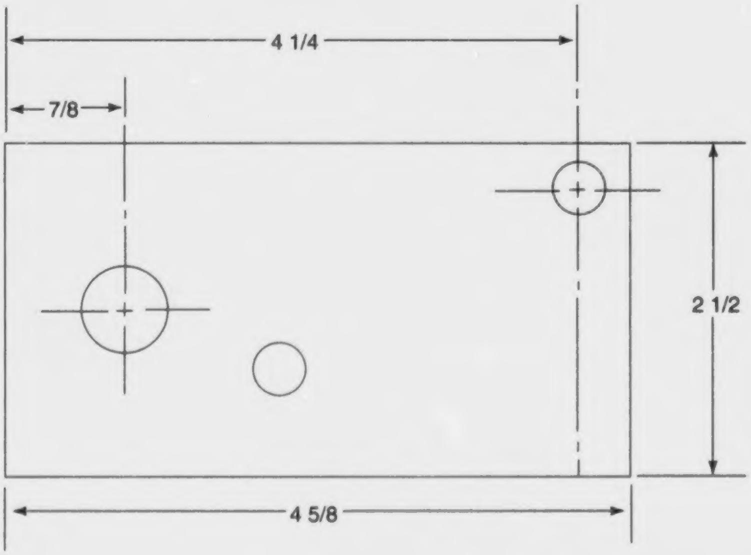

45°
Top
Side
Top
Front
Side
45°

Objective 5

Dimensioning

a. **Whole numbers and fractions**—Used in combination such as $2^1/_2$, $4^5/_8$, and normally used in welding when precise size is extremely remote

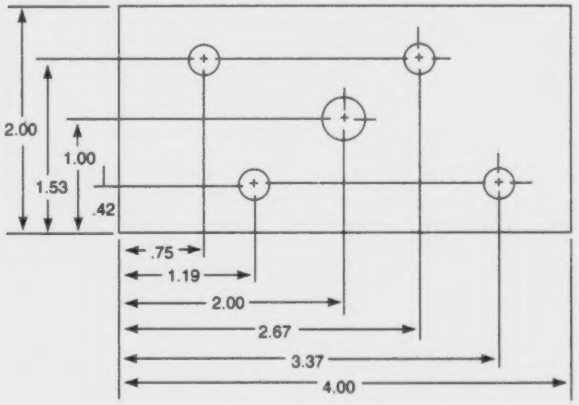
Figure 23



4 1/4
7/8
2 1/2
4 5/8

b. **Decimals**—Normally used in machine shop dimensioning when mating parts require precise measurements or when close tolerances are necessary

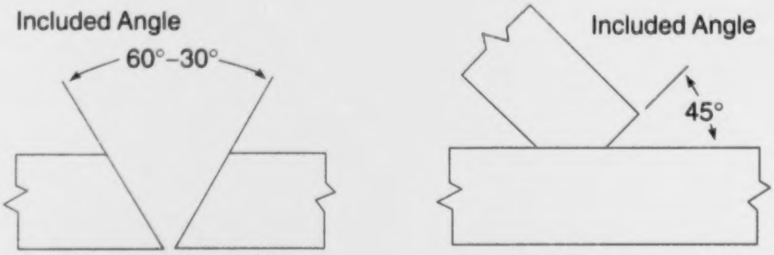
Figure 24



2.00
1.00
1.53
.42
.75
1.19
2.00
2.67
3.37
4.00

c. **Angular**—Used when a line is at an angle to a horizontal, vertical, or another angular line. The angle is called the "included angle" and is expressed in degrees or portions of degrees.

Figure 25



Angular-To-Horizontal Line
Degrees and Minutes

Angular-To-Horizontal Line

Objective 6

Tolerancing

a. Tolerancing with decimals means that dimensions are in decimal form and usually tolerancing is stated as a plus or minus.

Example: 5.425 ± .010 would be read as:
Five and 425 thousandths of an inch plus or minus ten thousandths of an inch. Expressed in decimals, the dimensions would be:
Max. 5.425 + .010 = 5.435
Min. 5.425 – .010 = 5.415

b. Tolerance is sometimes stated as total tolerance which in the example above would be the total of .010 + .010 or .020.

c. Tolerancing with fractions means that dimensions are in whole numbers, fractions, or combinations of both.

Example: $5\frac{5}{8}'' \pm \frac{1}{8}''$
Max. $5\frac{5}{8} + \frac{1}{8} = 5\frac{6}{8}$ or $5\frac{3}{4}$
Min. $5\frac{5}{8} - \frac{1}{8} = 5\frac{4}{8}$ or $5\frac{1}{2}$

d. Tolerancing with degrees means that dimensions are related to the 360 degrees in a circle with 60 minutes equalling 1 degree, and minutes, in this case, refer to distance, not time.

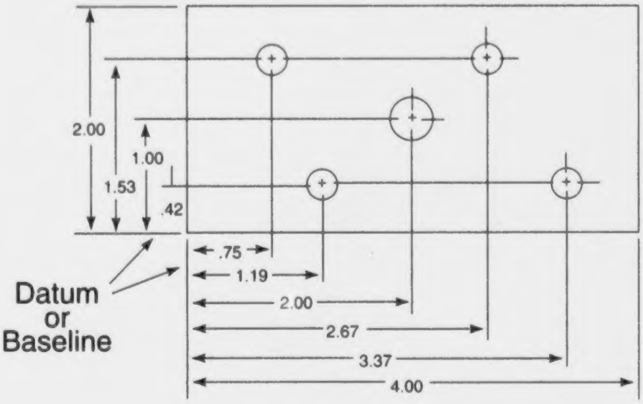
Example: 60 minutes = 1 degree and is notated at 60′
Max. 45° + 2° 30′ = 47° 30′
Min. 45° – 2° 30′ = 42° 30′

Objective 7

Methods of dimensioning

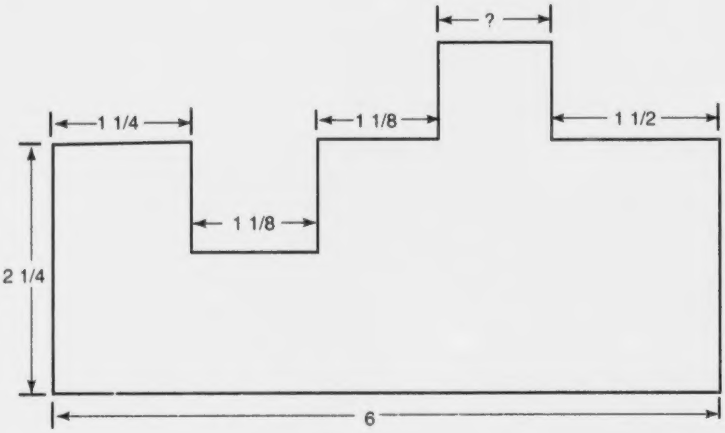
a. **Baseline or datum line**—A dimensioning method used when all dimensions on an object originate from a horizontal or vertical baseline or datum line

Figure 26


2.00
1.53
1.00
.42
Datum or Baseline
.75
1.19
2.00
2.67
3.37
4.00

b. **Conventional**—A method used when no set pattern is used for dimensioning and overall height, width, and length are usually given, but other dimensions may require addition or subtraction

Figure 27


?
1 1/4
1 1/8
1 1/2
1 1/8
2 1/4
6

Objective 8

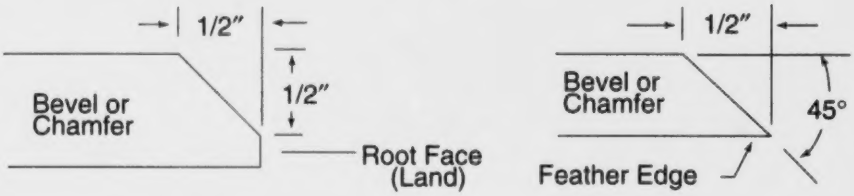
Bevels and chamfers

a. A bevel is a sloping surface which extends the full or partial length of an edge.

b. Chamfer is another term used for bevel, but chamfer is normally used in machine shop practice while bevel is used in welding applications.

Note: Dimensioning methods for bevels and chamfers are shown in the following graphic.

Figure 28


1/2″
1/2″
Bevel or Chamfer
Root Face (Land)
1/2″
Bevel or Chamfer
45°
Feather Edge

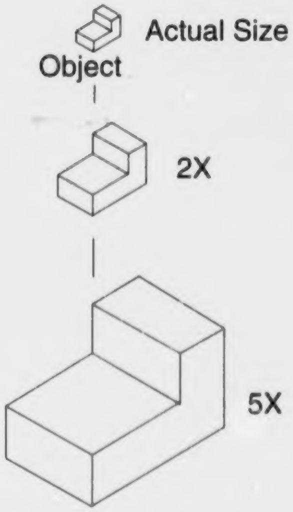
Objective 9

Reduction and enlargement scales

a. An enlargement scale presents an object larger than its actual size, usually twice as large, 2x, three times as large, 3x, 4x, 5x, and to the ratio required.

Figure 29

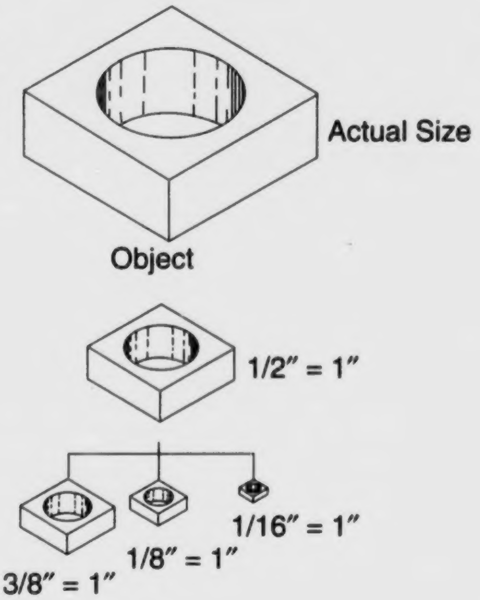
Example:
2″ = 1″
3″ = 1″
5″ = 1″


Actual Size
Object
2X
5X

b. A reduction scale presents an object smaller than its actual size, usually half size, quarter size, and as needed with the ratio expressed in fractions and inches.

Figure 30

Example:
1/2" = 1"
3/8" = 1"
1/8" = 1"
1/16" = 1"

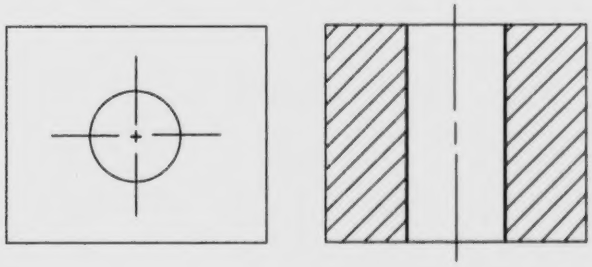


Objective 10

Types of holes

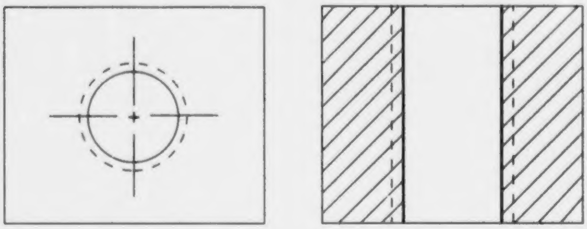
a. **Drilled**—A smooth sided hole that is made with a fractional size (1/16, 1/8), letter size (F, E), or number size (6, 8, 12) drill bit; the hole is to go all the way through unless depth is dimensioned

Figure 31



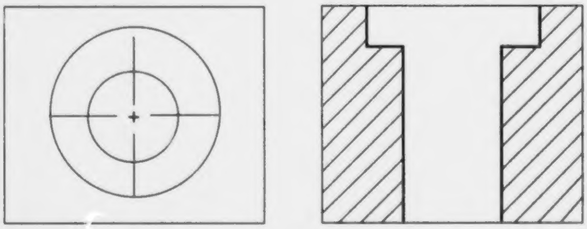
b. **Threaded**—A hole drilled and then threads cut on the sides of the hole for the insertion of proper sized bolts

Figure 32



c. **Counterbore**—A hole enlarged to a certain size and depth for counterbore bolts to be recessed. Provides a smooth top surface

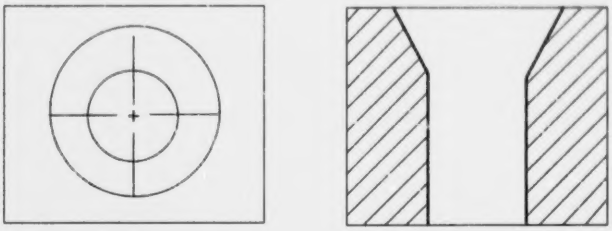
Figure 33



Note: Dimensions that must be applied to a counterbored hole include drill size for threaded hole, diameter or counterbore, and depth of counterbore.

d. **Countersunk**—A hole enlarged with beveled edge angles to a certain degree and diameter in order to allow a countersunk bolt to be recessed. Provides a smooth top surface

Figure 34



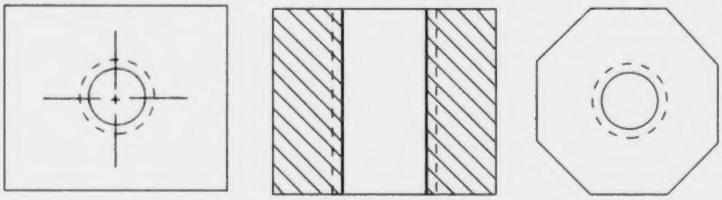
Note: The dimensions that must be applied to a countersunk hole include drill size for the threaded hole, diameter of the countersink, and degree of countersink.

Objective 11

Threads

a. Internal threads are cut on the inside of a drilled hole or nut.

Figure 35

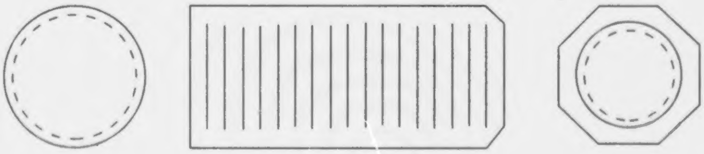


b. Information that must be applied to internal threads includes:

3/4	10	UNC	3	A	L.H.
Diameter	Threads per inch	Tread series	Class of fit	Internal	If left handed

c. External threads are cut on the outside of a bolt or screw.

Figure 36



d. Information that must be applied to external threads includes:

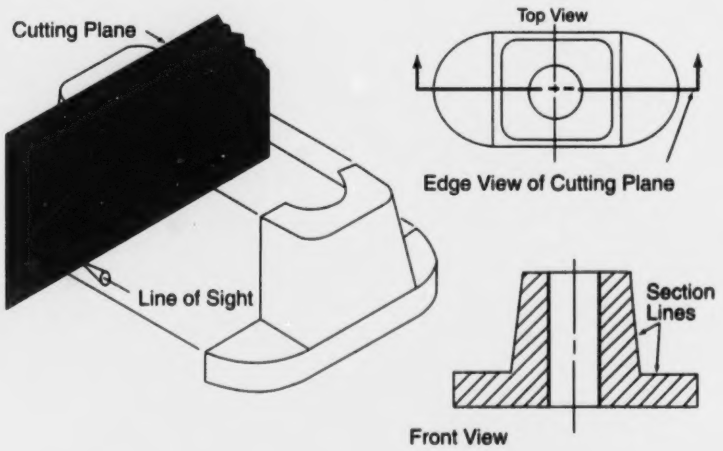
3/4	10	UNC	3	B	
Diameter	Threads per inch	Tread series	Class of fit	External	If right hand thread this area is left blank

Objective 12

Types of section views

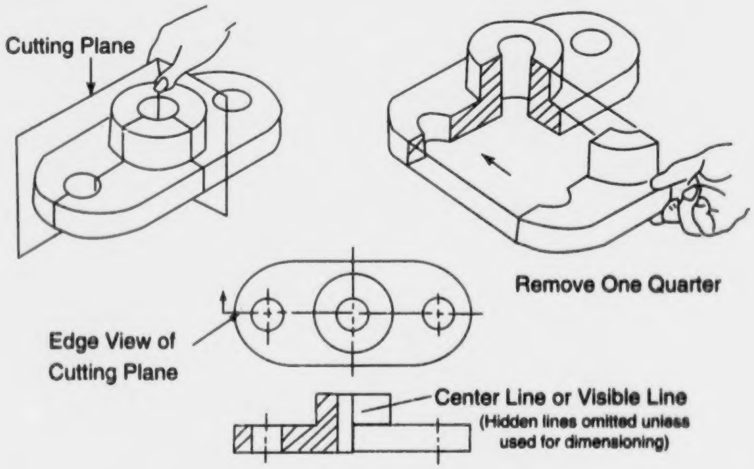
a. A full section view presents a cross section of an object so that it appears to have been cut entirely in half.

Figure 37


Cutting Plane
Top View
Edge View of Cutting Plane
Line of Sight
Section Lines
Front View

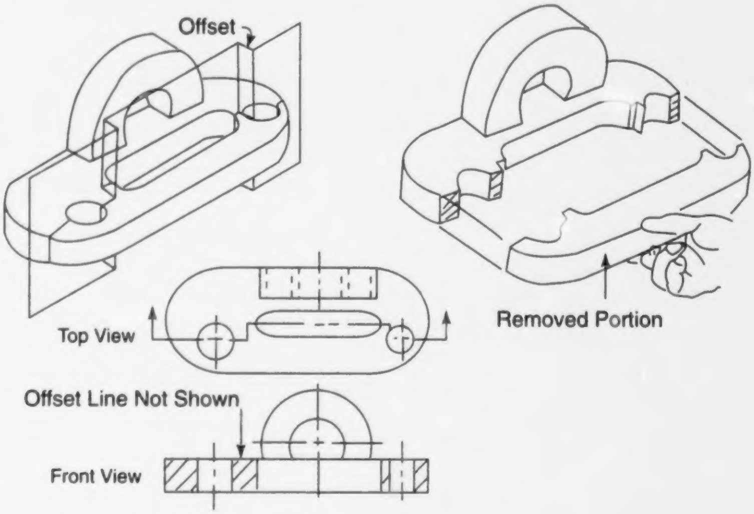
b. A half section view presents a cross section of an object so that it appears to have had a quarter section cut out of it.

Figure 38


Cutting Plane
Remove One Quarter
Edge View of Cutting Plane
Center Line or Visible Line
(Hidden lines omitted unless used for dimensioning)

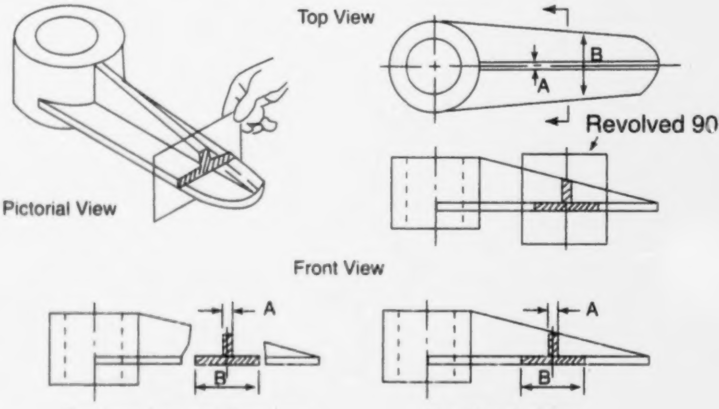
c. An offset section presents a cross section/view of an object so that it appears to have been cut entirely in half, but along an offset line.

Figure 39


Offset
Removed Portion
Top View
Offset Line Not Shown
Front View

d. A revolved section presents a cross section view of an object so that it appears to have been cut at a point and then rotated 90° so that shape and material composition can be shown.

Figure 40


Top View
B
A
Revolved 90°
Pictorial View
Front View
A
B
A
B

Broken Around Section

Section in View

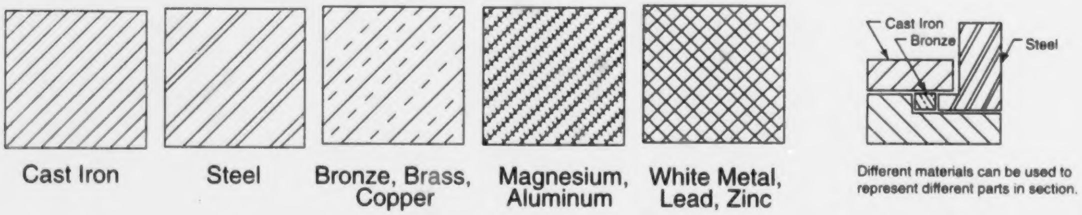
Information Sheet

Objective 13

Other symbols

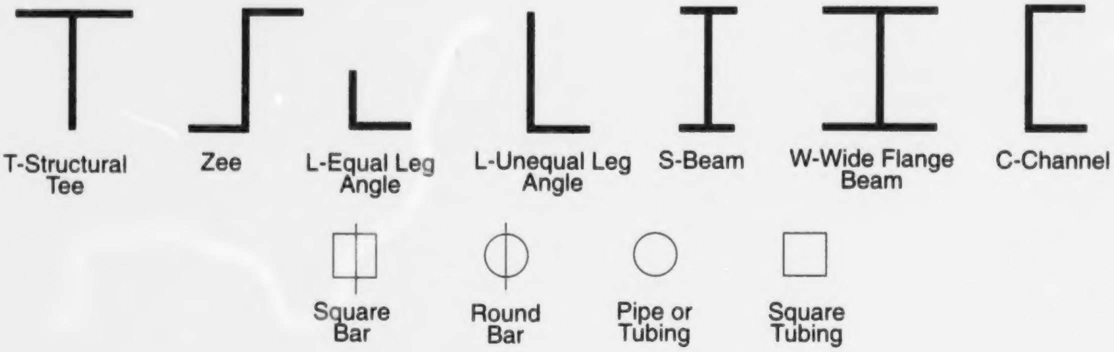
a. Material symbols use cross hatching lines to indicate composition of materials.

Figure 41


Cast Iron
Steel
Bronze, Brass, Copper
Magnesium, Aluminum
White Metal, Lead, Zinc
Cast Iron
Bronze
Steel
Different materials can be used to represent different parts in section.

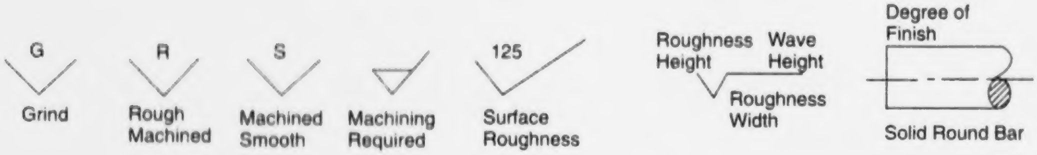
b. Stock components are depicted with lines that show their structural shapes.

Figure 42


T-Structural Tee
Zee
L-Equal Leg Angle
L-Unequal Leg Angle
S-Beam
W-Wide Flange Beam
C-Channel
Square Bar
Round Bar
Pipe or Tubing
Square Tubing

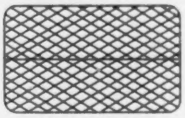
c. Machine symbols indicate to what degree of smoothness a surface should be finished.

Figure 43


G
Grind
R
Rough Machined
S
Machined Smooth
Machining Required
125
Surface Roughness
Roughness Height
Wave Height
Roughness Width
Degree of Finish
Solid Round Bar

d. A knurling symbol is used to indicate that a gripping surface should be provided on a normally smooth surface.

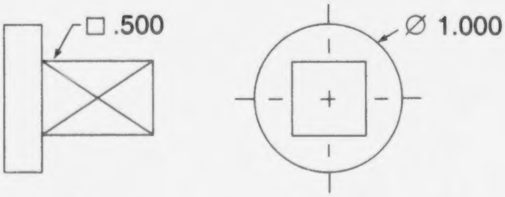
Figure 44



Knurling

e. An X through a part indicates that an object is square when viewed from a side angle.

Figure 45



Front

Side

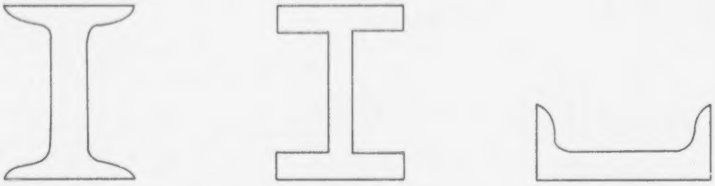
Objective 14

Structural shapes

a. Many structural shapes are common to all varieties of structural fabrication.

b. The symbols for structural shapes are miniature pictorials of the shapes themselves.

Figure 46



S Beam

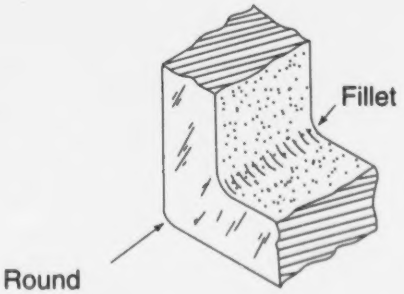
WF Beam

Channel

c. The fillet shape is an inside corner of a 90° angle whether machined smoothly or welded.

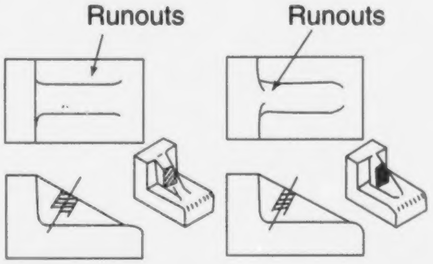
d. The round shape is an outside 90° corner.

Figure 47



e. A runout is a smooth continuation of a change in direction to avoid a weakened area that could result from an abrupt change.

Figure 48



Objective 15

Requirements for a formal bill of material

a. It should list the name of the firm that made the blueprint drawing, the name of the firm for whom the drawing was made, and list the drafter's initials, date of drawing, and initials of the drafting supervisor who checked the print.

b. It should list the part name last and items that define the part should precede the name.

Example: In the lower right hand of TM 1, the part is a Reflux Accumulator, and "from and to a depropanizer" indicates the specification position of the part in a flow line.

c. It should detail parts by groups such as pipe, valves, flanges, and fittings, and all groups and parts should have mark numbers (MK) so they can be easily referred to in a numerical sequence.

d. It should specify quantities required, sizes required, and information relating specific grades, brand names, or standards to which the part must comply.

e. It should clarify notes with important information taken directly from the blueprint for drawing, and related references to job number, location, and other materials necessary to properly relate the material list to the specific application that the print calls for.

Objective 16

Requirements for an informal bill of material

a. It should arrange the materials in numerical order.

b. It should identify materials by a mark number (MK) in numerical sequence.

c. It should specify the number required for each part.

d. It should clearly define size or dimension of parts that require such information.

e. It should note any other information that helps to clarify quality of material or elements in the original print or drawing that should be a reference for better understanding of what the part or material is used for.

Student Supplement 1—Common Abbreviations and Their Meanings

AISI—American Iron and Steel Institute

ANSI — American National Standards Institute

ASME—American Society of Mechanical Engineers

ASTM—American Society for Testing and Materials

AWG—American Wire Gage

AWS—American Welding Society

ASSY—Assembly

BC—Bolt Circle

BEV—Bevel

B/M—Bill of material

BWG—Birmingham Wire Gage

B&S—Browne & Sharpe Wire Gage

BRS #—Brass, SAE #

BRZ #—Bronze, SAE #

C TO C—Center to center

CBORE—Counterbore

CDRILL—Counterdrill

CHAM—Chamfer

CI—Cast iron

CL ℄—Center line

CRS—Cold rolled steel

CS—Cast steel

CSK—Countersink

DEG or °—Degree(s)

DIA or ⌀—Diameter

DIM—Dimension

DWG—Drawing

FAB—Fabricate

FAO—Finish all over

FT or '—Foot, feet

GA—Gage or gauge

HRS—Hot rolled steel

ID—Inside diameter

In or "—Inch, inches

KWY—Keyway

LB or #—Pound, pounds

LH—Left hand

MATL—Material

MI—Malleable iron

MIL-STD—Military standard

MIN or '—Minute, minutes

mm—Millimeter

MS—Mild steel

NDT—Nondestructive testing

NO #—Number

NTS—Not to scale

OC—On center

Student Supplement 1

OD—Outside diameter

P—Pitch

PC—Piece, pieces

PL—Plate

PSI—Pounds per square inch

RAD—Radius

REF L—Reference line

REQD—Required

RD—Round

RPM—Revolutions per minute

S—S beam

SAE—Society of Automotive Engineers

SCH—Schedule

SQ FT—Square foot, feet

SQ IN—Square inch, inches

SQ or ☐ —Square

SST—Stainless steel

STD—Standard

STL—Steel

TYP—Typical

V—Volt

VOL—Volume

W—Watt

WT—Weight

WI—Wrought iron

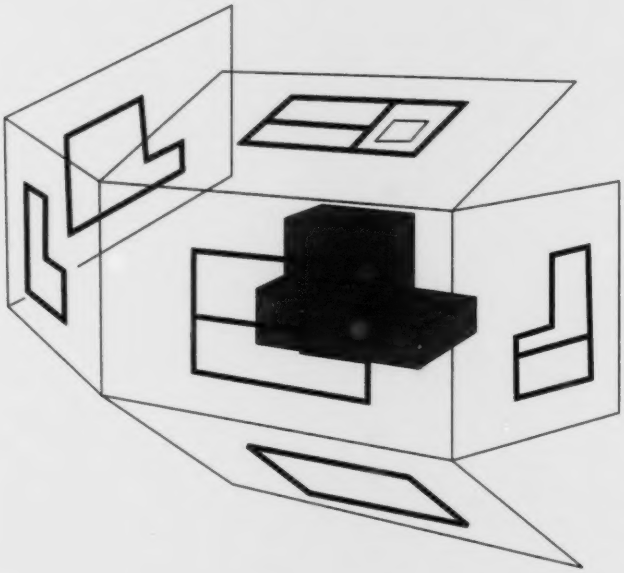
YD—Yard, yards

X, x—Multiply by, times, places

Student Supplement 2—Orthographic Projection

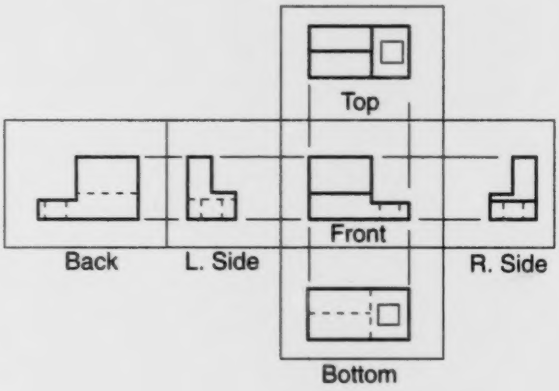
Basis

In an orthographic projection, all planes revolve until they align with a frontal plane which is referred to as the front view.



Managing orthographic views

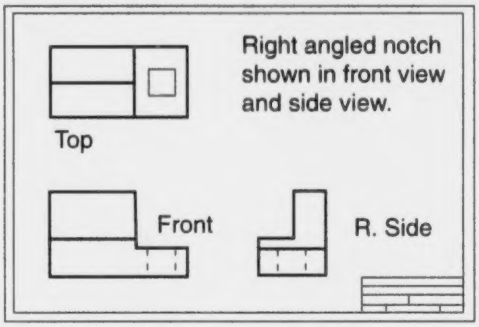
Orthographic views align with the frontal plane of an object, but can provide a view of an object from the top, front, right side, left side, bottom, and back.



Student Supplement 2

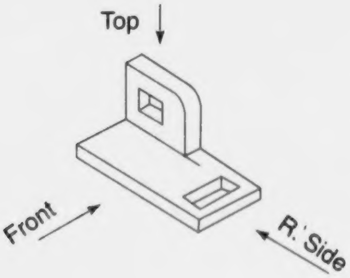
Principal views and positioning

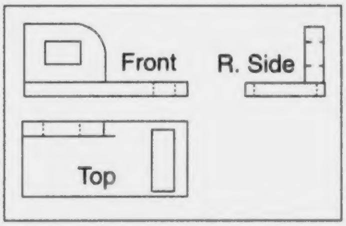
The front, top and side views are the principal views used in orthographic projections.


Top
Front
R. Side

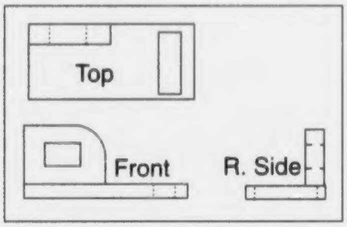
Right angled notch shown in front view and side view.

In presentation, the top view should be above and aligned with the front view and the side view should also be aligned with the front view.

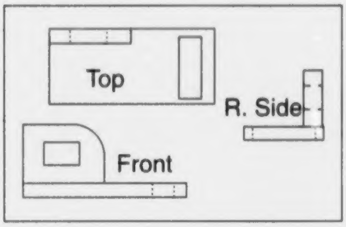

Top
Front
R. Side


Front
R. Side
Top

INCORRECT—Top Should Be Above Front


Top
Front
R. Side

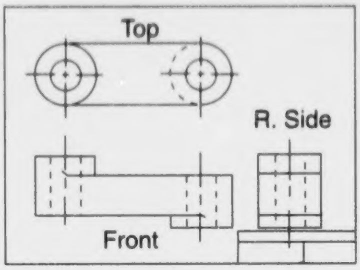
CORRECT


Top
R. Side
Front

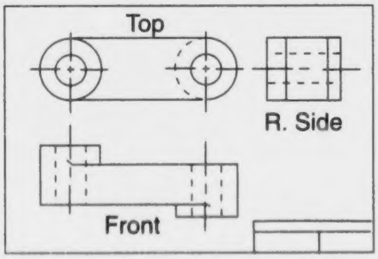
INCORRECT—Views Not Lined Up

Positioning the side view

As previously shown, the normal location of the side view is projected off the front view, but alternate positioning is acceptable when space in the normal location is occupied. In such a situation, the side view should be aligned with the top view as an alternative location.



Normal Location



Alternate Location

Significance

In general, pictorials make objects on a flat surface easier to visualize. Orthographic projections not only help with the visualization, but project details that relate planes of an object to its entire shape. In turn, this provides more accurate reference in fabrication of complex products.

Basic Welding Joints and Symbols

Unit Contents

Student Components

	Student Page
Learning Activities Sheet	8–3
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Information Sheet	8–7
Student Supplement	
1—Weld Symbols, Names, and Definitions	8–25
*Assignment Sheets	
1—Identify Basic Weld Symbols	127
2—Interpret Basic Welding Symbols	129
3—Interpret Working Welding Symbols	133
4—Draw Welding Symbols for Given Specifications	141
5—Interpret a Welding Print and Welding Procedure Specifications	145

*Assignment Sheets are located in the Student Workbook.

Prerequisites:
None

Learning Activities Sheet

Student Name ____

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objectives 1 through 10.

☐ 4. **Read** Student Supplement 1, "Weld Symbols, Names, and Definitions."

☐ 5. **Do** Information Sheet, Objectives 11 through 14.

☐ 6. **Stop** Assignment Sheet 1, "Identify Basic Weld Symbols".

☐ 7. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 8. If the evaluation is not satisfactory, repeat Steps 5 and 6.

☐ 8. **Do** Assignment Sheet 2, "Interpret Basic Welding Symbols."

☐ 9. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 10. If the evaluation is not satisfactory, repeat Steps 5 and 8.

☐ 10. **Do** Assignment Sheet 3, "Interpret Working Welding Symbols."

☐ 11. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 12. If the evaluation is not satisfactory, repeat Steps 5 and 10.

☐ 12. **Do** Assignment Sheet 4, "Draw Welding Symbols for Given Specifications."

☐ 13. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 14. If the evaluation is not satisfactory, repeat Steps 5 and 12.

☐ 14. **Do** Assignment Sheet 5, "Interpret a Welding Print and Welding Procedure Specifications."

☐ 15. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 16. If the evaluation is not satisfactory, repeat Steps 5 and 14.

☐ 16. **Check** With instructor for any additional assignments to be completed.

☐ 17. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 18. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Objective Sheet

Unit Objective

After completing this unit, the student should be able to identify basic welding symbols, interpret basic welding symbols, interpret working welding symbols, draw welding symbols for given specifications, and interpret a welding print and welding procedure specifications. The student should demonstrate these competencies by completing the assignment sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to basic welding joints and symbols with their correct definitions.
2. Complete statements about basic parts of a welding symbol.
3. Complete statements about arrow side, other side significance.
4. Select true statements about arrow line variations.
5. Differentiate between weld symbols and welding symbols.
6. Identify supplementary symbols.
7. Identify contour and finish symbols.
8. Interpret information in a welding symbol tail.
9. Identify basic welding joints.
10. Interpret basic welding symbols.
11. Apply basic rules for locating dimensions.
12. Apply additional dimensioning symbols to fillet welds.
13. Interpret nondestructive testing symbols.
14. Select true statements about procedures for fitting up and welding structural shapes.

*15. Identify basic weld symbols. (Assignment Sheet 1)

*16. Interpret basic welding symbols. (Assignment Sheet 2)

*17. Interpret working welding symbols. (Assignment Sheet 3)

*18. Draw welding symbols for given specifications. (Assignment Sheet 4)

*19. Interpret a welding print and welding procedure specifications. (Assignment Sheet 5)

*Assignment Sheets are located in the Student Workbook.

Information Sheet

Objective 1

Terms and definitions

a. **Concave**—Rounded or curved inward in relation to adjoining planes

b. **Consumable insert**—Preplaced filler metal that is completely fused into the joint root and becomes part of the weld

c. **Convex**—Rounded or curved outward in relation to adjoining planes

d. **Flush**—Forming a relatively level or continuous plane on a surface

e. **Fillet weld**—A weld of approximately triangular cross section joining two surfaces approximately at right angles to each other in a lap joint, T-joint, or corner joint

f. **Groove weld**—A weld made in the groove between workpieces

g. **Miter**—The beveled edges of workpieces made by cutting two pieces at angles and joining them

h. **Pitch**—The center-to-center distance between two welds

i. **Welding symbol**—A graphical representation of a weld

j. **Weld symbol**—A graphical character connected to the welding symbol indicating the type of weld

k. **Workpiece**—The part that is welded, brazed, soldered, thermal cut, or thermal sprayed

Objective 2

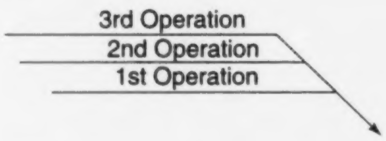
Basic parts of a welding symbol

a. A reference line is a straight line on a horizontal plane with all other welding information located above, below, or on the reference line.

Figure 1

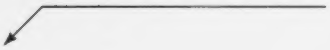
b. Multiple reference lines are used to indicate a sequence of welds or associated activity with the first weld of the series closest to the arrow.

Figure 2



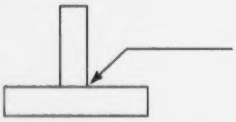
c. An arrow line extends at an angle from either end of a reference line and is terminated with an arrowhead.

Figure 3



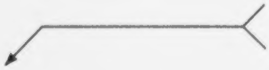
d. The arrow may point in any direction but it always points to the welding joint which requires preparation and/or welding.

Figure 4



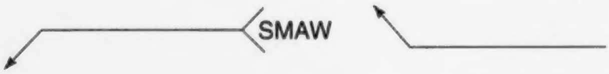
e. The tail of a welding symbol is at the end of a reference line, opposite the arrow and it has the horizontal V-shape of feathers at the end of an arrow.

Figure 5



f. The free space in the tail is used for notes, specifications, process, and other items, but if no instructions are required, the tail is not used.

Figure 6

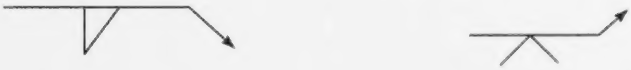


Objective 3

Arrow side, other side significance

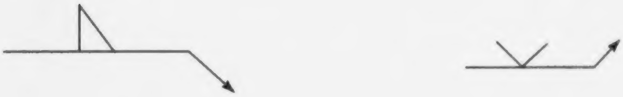
a. A weld symbol located beneath the reference line indicates the weld is to be made on the same side the arrow points to.

Figure 7



b. A weld symbol located above the reference line indicates the weld is to be made on the opposite side the arrow points to.

Figure 8

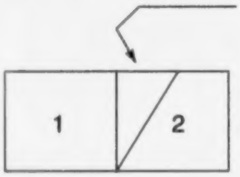


Objective 4

Arrow line variations

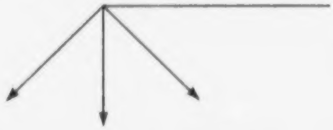
a. A broken arrow line points to the workpiece to be prepared, and is used on a bevel, J-joint, flare bevel, and corner flange.

Figure 9



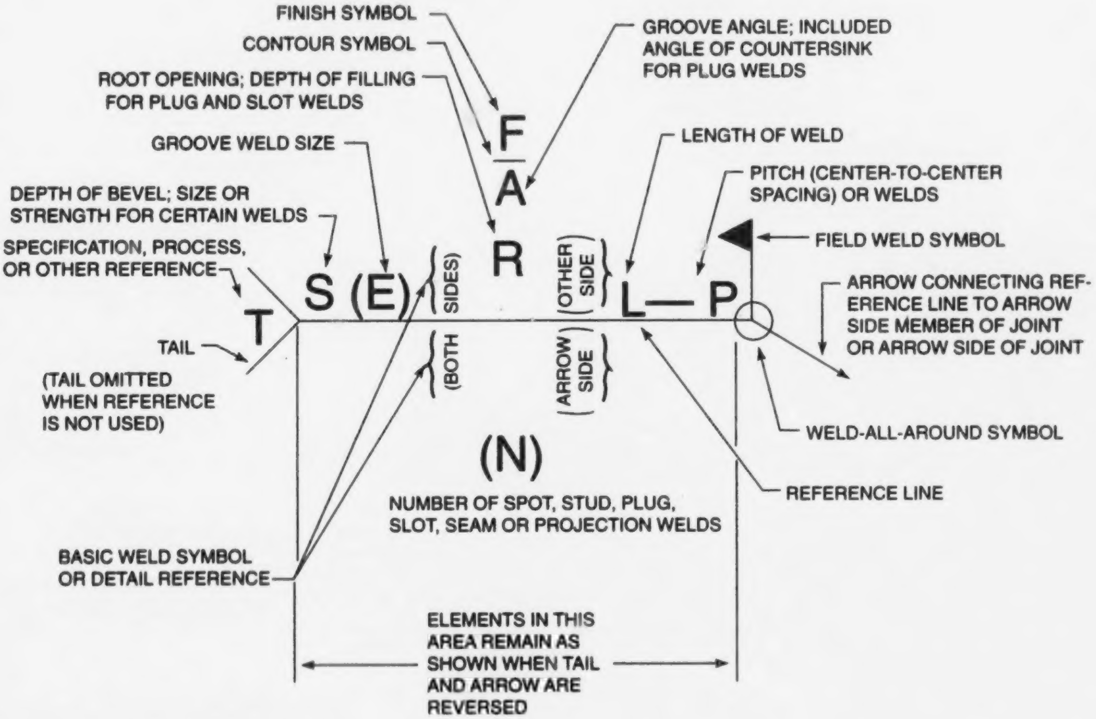
b. Multiple arrow lines are used to indicate that the same weld is required in several different places.

Figure 10



Objective 5

Weld symbols and welding symbols


FINISH SYMBOL
CONTOUR SYMBOL
ROOT OPENING; DEPTH OF FILLING FOR PLUG AND SLOT WELDS
GROOVE WELD SIZE
DEPTH OF BEVEL; SIZE OR STRENGTH FOR CERTAIN WELDS
SPECIFICATION, PROCESS, OR OTHER REFERENCE
TAIL
(TAIL OMITTED WHEN REFERENCE IS NOT USED)
GROOVE ANGLE; INCLUDED ANGLE OF COUNTERSINK FOR PLUG WELDS
LENGTH OF WELD
PITCH (CENTER-TO-CENTER SPACING) OR WELDS
FIELD WELD SYMBOL
ARROW CONNECTING REFERENCE LINE TO ARROW SIDE MEMBER OF JOINT OR ARROW SIDE OF JOINT
WELD-ALL-AROUND SYMBOL
REFERENCE LINE
F
A
R
T
S (E)
(BOTH SIDES)
(OTHER SIDE)
(ARROW SIDE)
L — P
(N)
NUMBER OF SPOT, STUD, PLUG, SLOT, SEAM OR PROJECTION WELDS
BASIC WELD SYMBOL OR DETAIL REFERENCE
ELEMENTS IN THIS AREA REMAIN AS SHOWN WHEN TAIL AND ARROW ARE REVERSED

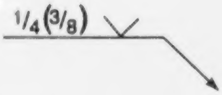
Courtesy American Welding Society

a. A weld symbol is a shape designed to represent a basic weld.

Example:
∨ is V-groove butt weld
◺ is a fillet weld
▭ is a plug or slot weld

b. A welding symbol has the weld symbol on the reference line along with all other information significant to the weld.

Figure 11



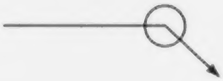
Example: In the graphic above, the v-groove specified should be $^1/_4$" in depth and shall be made on the other side of the joint with a $^3/_8$" weld.

Objective 6

Supplementary symbols

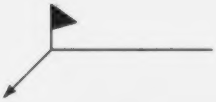
a. The weld all around symbol is an open circle position at the junction of the reference line and the arrow line, indicating that the weld is to be made all around the joint.

Figure 12



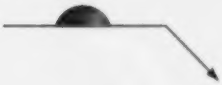
b. A field weld symbol is a darkened flag located at the junction of the reference/arrow lines, indicating the weld is to be made at the job site, not in the shop.

Figure 13



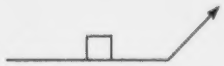
c. A melt through symbol is a solid oval located on the opposite side of the weld symbol, indicating a requirement for 100% penetration.

Figure 14



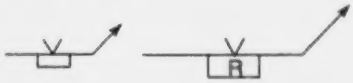
d. A consumable insert symbol is an open square box located on the reference line, indicating that an insert is consumed in the basic weld.

Figure 15



e. A backing symbol is an open rectangular box used in combination with a groove weld symbol; the symbol is located on the reference line, indicating that backing material is required on the opposite side of the weld to control penetration.

Figure 16

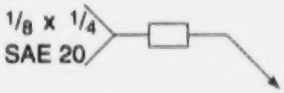


f. If backing is to be removed after completion of the weld, there will be an R in the backing symbol.

g. A spacer symbol is an open rectangular box that intersects the reference line, indicating that a spacer is required in the joint.

Note: Spacer and backing size and material are normally placed in the tail of the arrow.

Figure 17

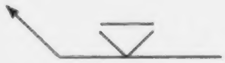


Objective 7

Contour and finish symbols

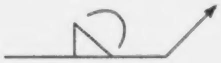
a. A flush contour symbol is located on the same side as the symbol and indicates the weld should be made on approximately a flat plane with the surface.

Figure 18



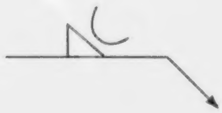
b. A convex contour symbol is located on the same side as the symbol and indicates that the weld should have a raised or convex shape.

Figure 19



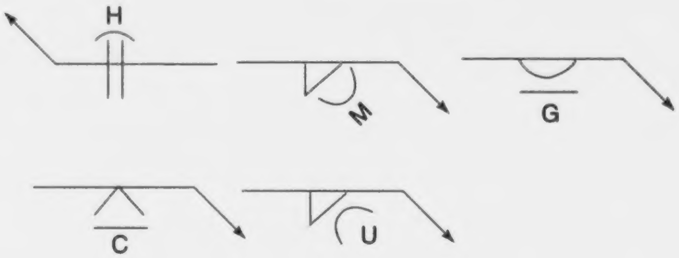
c. A concave contour symbol is located on the same side as the symbol and indicates that the weld should have a depressed or concave shape.

Figure 20



d. If a contour requires finishing, a finishing symbol will be used in conjunction with the contour symbol, a letter G to indicate grinding, C to indicate chipping, H to indicate hammering, M to indicate machining, and U to indicate unspecified which means the best local method should be used.

Figure 21



Objective 8

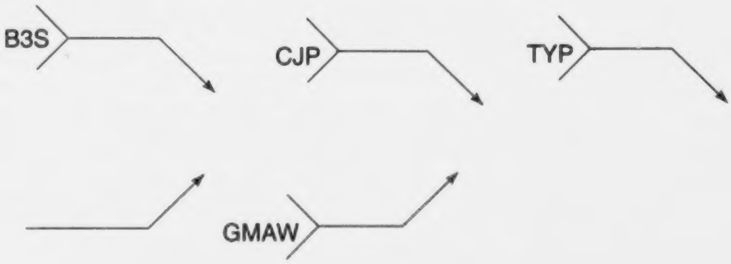
Information in a welding symbol tail

a. When a specification, process, test, or other reference is needed to clarify a welding symbol, the reference is placed in the tail of the welding symbol.

b. The letters CJP (complete joint penetration) indicate that a complete joint penetration groove weld is required regardless of the type of weld or joint preparation.

c. The tail may be omitted when no specifications, process, or other reference is required with a welding symbol.

Figure 22

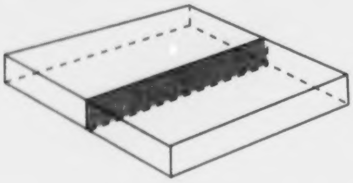


Objective 9

Basic welding joints

a. A butt joint is a joint between two members aligned approximately in the same plane.

Figure 23



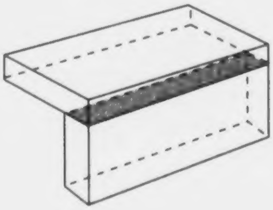
APPLICABLE WELDS

BEVEL-GROOVE
FLARE-BEVEL-GROOVE
FLARE-V-GROOVE
J-GROOVE
SQUARE-GROOVE
U-GROOVE
V-GROOVE
EDGE-FLANGE
BRAZE

Courtesy American Welding Society

b. A corner joint is a joint between two members located approximately at right angles to each other.

Figure 24



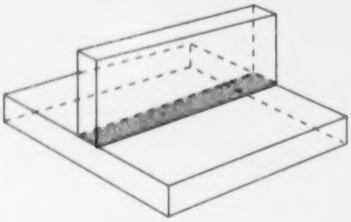
APPLICABLE WELDS

FILLET
BEVEL-GROOVE
FLARE-BEVEL-GROOVE
FLARE-V-GROOVE
J-GROOVE
SQUARE-GROOVE
U-GROOVE
V-GROOVE
CORNER-FLANGE
EDGE-FLANGE
PLUG
SLOT
SPOT
SEAM
PROJECTION
BRAZE

Courtesy American Welding Society

c. A T-joint is a joint between two members located approximately at right angles to each other in the form of a T.

Figure 25



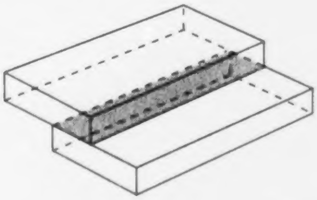
APPLICABLE WELDS

FILLET
BEVEL-GROOVE
FLARE-BEVEL-GROOVE
J-GROOVE
SQUARE-GROOVE
PLUG
SLOT
SPOT
SEAM
PROJECTION
BRAZE

Courtesy American Welding Society

d. A lap joint is a joint between two overlapping members in parallel planes.

Figure 26



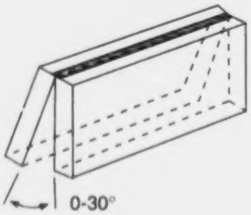
APPLICABLE WELDS

FILLET
BEVEL-GROOVE
FLARE-BEVEL-GROOVE
J-GROOVE
PLUG
SLOT
SPOT
SEAM
PROJECTION
BRAZE

Courtesy American Welding Society

e. An edge joint is a joint between the edges of two or more parallel or nearly parallel members.

Figure 27



APPLICABLE WELDS

BEVEL-GROOVE
FLARE-BEVEL-GROOVE
FLARE-V-GROOVE
J-GROOVE
SQUARE-GROOVE
U-GROOVE

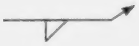
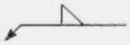
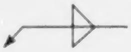
V-GROOVE
EDGE
CORNER-FLANGE
EDGE-FLANGE
SEAM

Courtesy American Welding Society

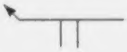
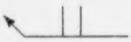
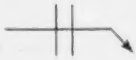
Objective 10

Basic welding symbols

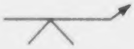
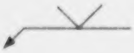
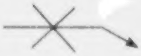
a. Fillet Weld:

- Arrow side: 
- Other side: 
- Both sides: 

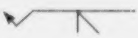
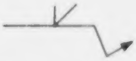
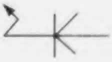
b. Square groove:

- Arrow side: 
- Other side: 
- Both sides: 

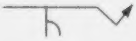
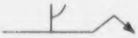
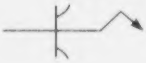
c. V-groove:

- Arrow side: 
- Other side: 
- Both sides: 

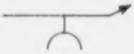
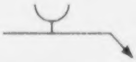
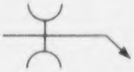
d. Bevel groove:

- Arrow side: 
- Other side: 
- Both sides: 

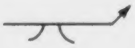
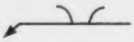
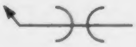
e. J-groove:

- Arrow side: 
- Other side: 
- Both sides: 

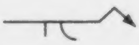
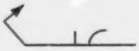
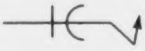
f. U-groove:

- Arrow side: 
- Other side: 
- Both sides: 

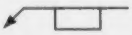
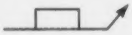
g. Flare V:

- Arrow side: 
- Other side: 
- Both sides: 

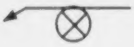
h. Flare-Bevel:

- Arrow side: 
- Other side: 
- Both sides: 

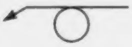
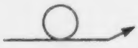
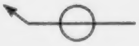
i. Plug or Slot:

- Arrow side: 
- Other side: 

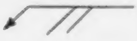
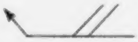
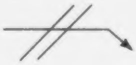
j. Stud:

- Arrow side: 

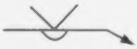
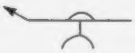
k. Spot or Projection

- Arrow side: 
- Other side: 
- No arrow/other side significance: 

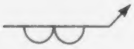
l. Scarf:

- Arrow side: 
- Other side: 
- Both sides: 

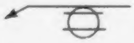
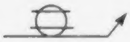
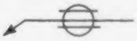
m. Back or backing:

- Arrow side: 
- Other side: 

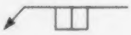
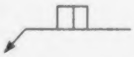
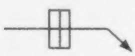
n. Surfacing:

- Arrow side: 

o. Seam

- Arrow side: 
- Other side: 
- Both sides: 

p. Edge flange:

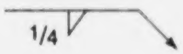
- Arrow side: 
- Other side: 
- Both sides: 

Objective 11

Basic rules for locating dimensions

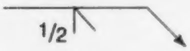
a. Excepting groove welds, the first number to the left of a weld symbol is weld size in inches.

Figure 28



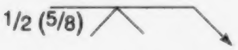
b. The first number to the left of groove weld symbols is groove depth in inches.

Figure 29



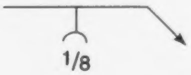
c. When a groove weld symbol shows both groove depth and size of weld, the groove size appears in parenthesis to the left of the symbol and the depth of bevel in inches appears to the left of the parenthesis.

Figure 30



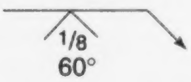
d. The first number inside groove weld symbols is the root opening in inches.

Figure 31



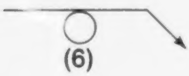
e. The second number inside groove weld symbols is the included angle in degrees.

Figure 32



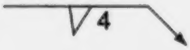
f. On resistance weld symbols, the number (in parenthesis) above or below the symbol indicates the number of welds to be made.

Figure 33



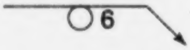
g. The first number to the right of weld symbols, except for circular welds, is length of weld in inches.

Figure 34



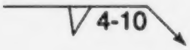
h. The first number to the right of circular welds is pitch or center to center distance in inches.

Figure 35



i. The second number to the right of other than circular welds is pitch in inches on center.

Figure 36

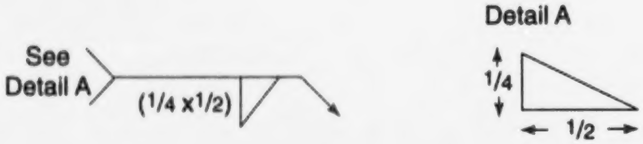


Objective 12

Additional dimensioning symbols for fillet welds

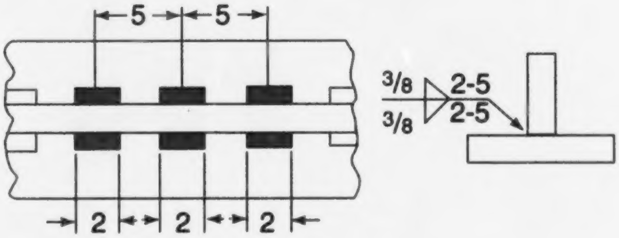
a. An unequal leg fillet weld symbol will have a note in the tail referencing a detailed drawing that will specify the size for each leg.

Figure 37



b. An intermittent fillet weld symbol has numbers to indicate length of the welds and the pitch or center to center distance, and the fillet weld symbol is aligned to indicate welds should be aligned opposite each other.

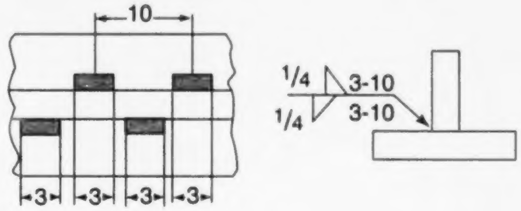
Figure 38



Courtesy American Welding Society

c. A staggered-intermittent weld fillet weld symbol has numbers to indicate length and pitch, but the fillet weld symbol is staggered on the reference line to indicate the welds should be staggered on each side of the joint.

Figure 39



Courtesy American Welding Society

Objective 13

Nondestructive testing symbols

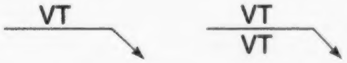
a. Frequently used symbols for nondestructive testing are:

- MT—Magnetic particle testing
- PT—Penetrant testing
- RT—Radiographic testing
- UT—Ultrasonic testing
- VT—Visual testing

Note: Other less frequently used nondestructive testing symbols are AET—Acoustical emission testing; ET—Electromagnetic testing; NRT—Neutron radiographic testing; and PT—Proof testing.

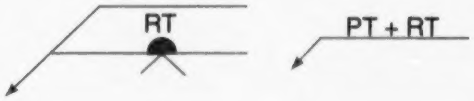
b. Nondestructive testing symbols may appear on or below the reference line, but if the symbol appears on both sides of the reference line, it means both sides of the joint require testing.

Figure 40



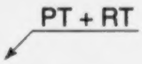
c. Nondestructive testing symbols may be combined with welding symbols or with each other if a welded workpiece is to be checked by two or more methods.

Figure 41



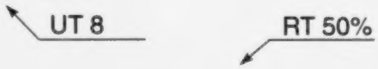
d. When two or more testing methods are required on the same joint, all tests will be listed in sequence with the first test closest to the arrow.

Figure 42



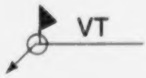
e. The number to the right of the testing symbol indicates length or percentage to be tested, with length meaning length in inches and percentage meaning a portion of the weld related to its total length.

Figure 43



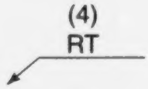
f. The test all around and field tests symbols are the same as their welding symbols, except that they pertain to testing.

Figure 44



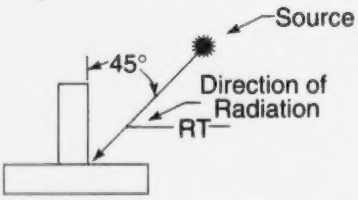
g. The number above or below the testing symbol indicates the number of tests required at specific locations or random selection as specified by contract.

Figure 45



h. Radiographic testing is so precise that test specifications may require specific test angles and locations and may be so noted in a reference.

Figure 46



Objective 14

Procedures for fitting up and welding structural shapes

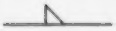
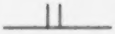
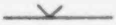
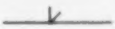
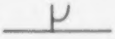
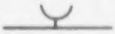
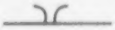
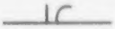
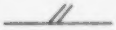
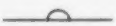
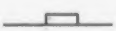
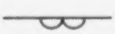
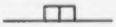
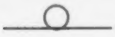
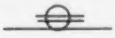
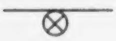
a. Structural shapes of the same or different sizes may be butted for fit-up and welding.

b. Structural shapes of the same or different sizes may be mitered for fit-up and welding.

c. Structural shapes of the same or different sizes may be notched for fit-up and welding.

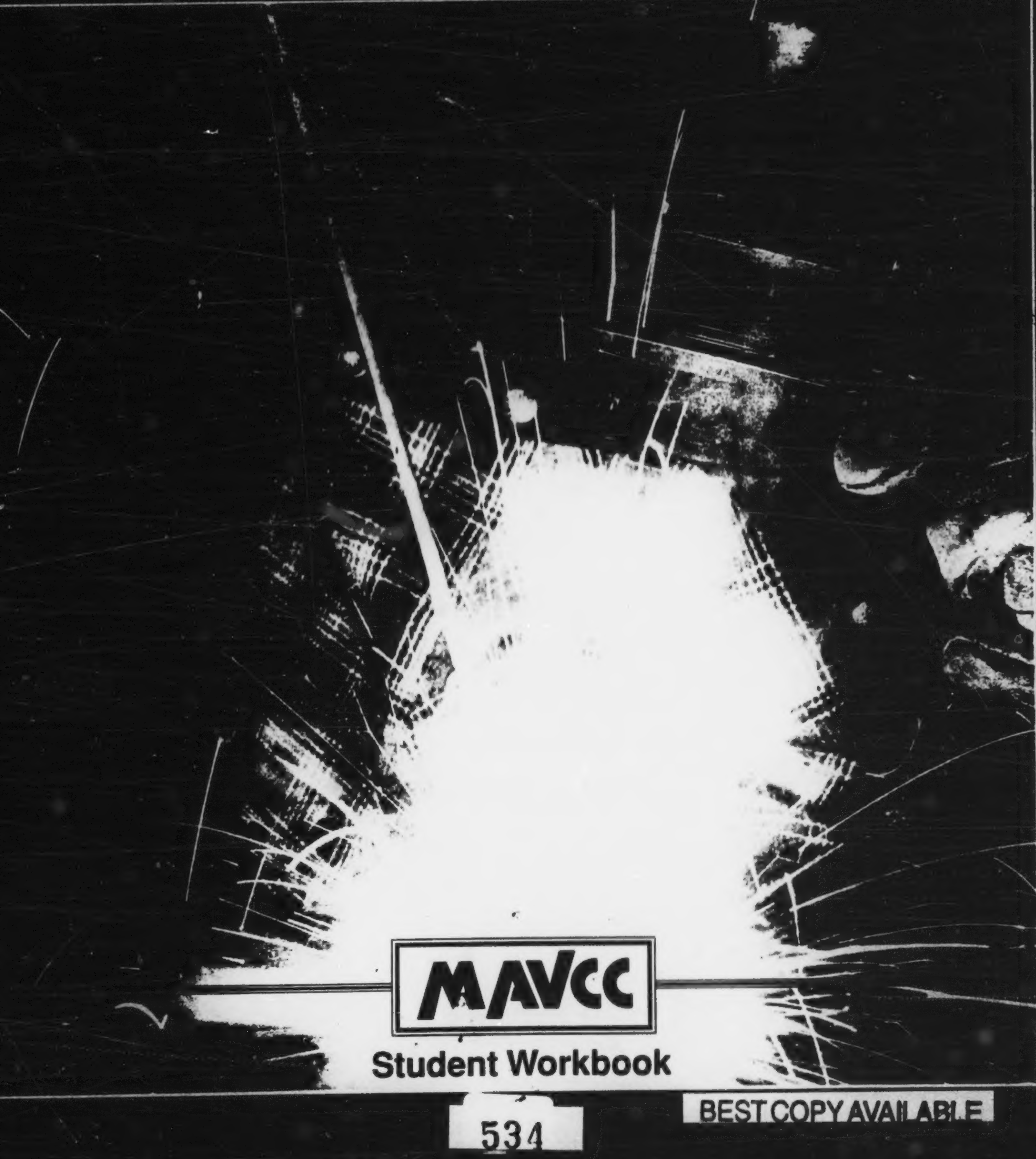
- Angle to angle
- Angle to channel
- Angle to S or W beams
- Channel to channel
- Channel to S or W beams
- S or W to S or W beams

Student Supplement 1—Weld Symbols, Names, and Definitions

Symbol	Name	Definition
1. 	Fillet weld	A weld of an approximately triangular cross section joining two surfaces approximately at right angles to each other in a lap joint, T-joint, or corner joint
	Groove Welds	A weld made in a groove between two workpieces
2. 	Square groove weld	Workpieces aligned on approximately a flat plane
3. 	V-groove weld	A groove in the shape of a V
4. 	Bevel groove weld	When only one or two workpieces are to be grooved
5. 	J-groove weld	A groove in the shape of a J on one workpiece
6. 	U-groove weld	A groove in the shape of a U
7. 	Flare V-groove weld	A groove when both workpieces are to be flared
8. 	Flare bevel groove weld	A groove when only one workpiece is to be flared
9. 	Scarf groove	A slanted square groove used only for brazing
	Other Welds	
10. 	Back or Backing weld	A back weld is distinguished from a backing weld only by the time of application
11. 	Plug or Slot weld	A plug weld is distinguished from a slot weld only by the shape of the hole
12. 	Surfacing weld	A weld used to build up workpieces for extended life
13. 	Edge flange weld	A weld used on the flanged edges of light gauge metal
14. 	Spot or projection weld	A spot weld is distinguished from a projection only by the welding process in the tail of the arrow
15. 	Seam weld	A continuous spot weld made with circular rotating electrodes
16. 	Stud weld	A weld made by joining studs to a metal workpiece for the purpose of anchoring concrete or other poured material

Fundamentals of Welding

Second Edition



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Student Workbook

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Fundamentals of Welding

Second Edition

Student Workbook

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Objective 12

Assignment Sheet 1—Identify Welding Processes

Name ____________________ Overall Rating __________

Date ____________________

Evaluation Criteria	Rating
• Number of correct process identifications	______

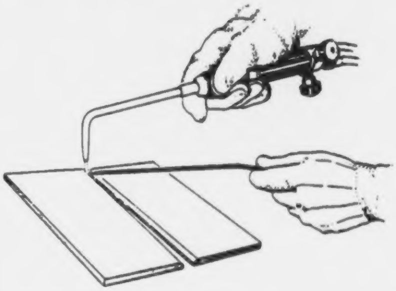
Basic Skills

Reading

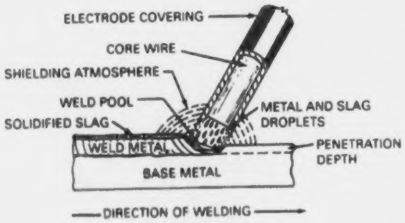
Critical Thinking

Directions

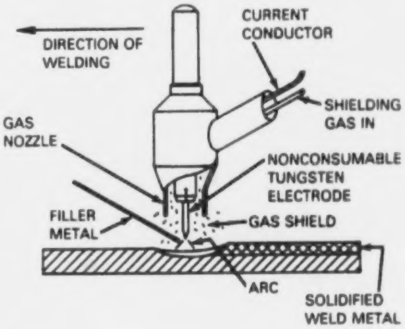
Examine the illustrations that follow. Insert the number of the process name beside the appropriate illustration.



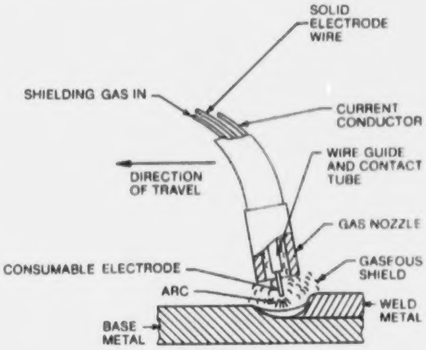
a. __________


ELECTRODE COVERING
CORE WIRE
SHIELDING ATMOSPHERE
WELD POOL
METAL AND SLAG DROPLETS
SOLIDIFIED SLAG
WELD METAL
PENETRATION DEPTH
BASE METAL
DIRECTION OF WELDING

b. __________


DIRECTION OF WELDING
CURRENT CONDUCTOR
SHIELDING GAS IN
GAS NOZZLE
NONCONSUMABLE TUNGSTEN ELECTRODE
FILLER METAL
GAS SHIELD
ARC
SOLIDIFIED WELD METAL

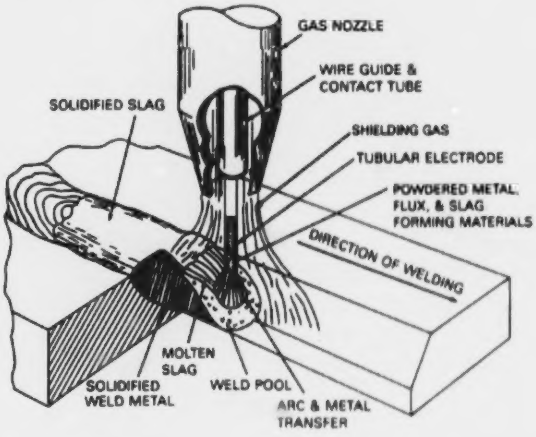
c. __________

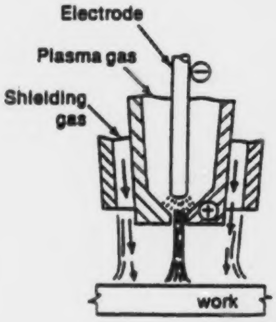

SOLID ELECTRODE WIRE
SHIELDING GAS IN
CURRENT CONDUCTOR
DIRECTION OF TRAVEL
WIRE GUIDE AND CONTACT TUBE
GAS NOZZLE
CONSUMABLE ELECTRODE
GASEOUS SHIELD
ARC
WELD METAL
BASE METAL

d. __________

1. GMAW
2. SMAW
3. OFW
4. GTAW

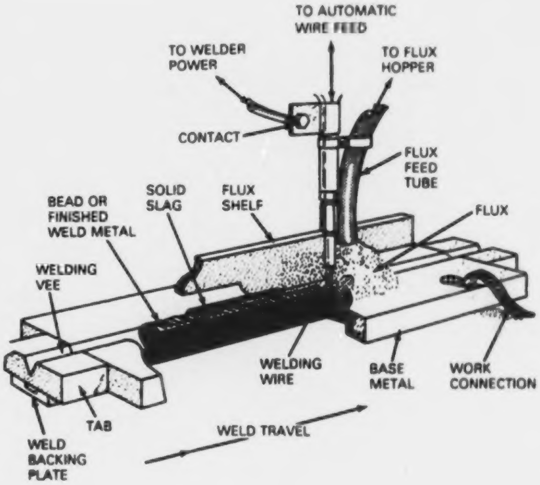
BEST COPY AVAILABLE


GAS NOZZLE
WIRE GUIDE & CONTACT TUBE
SOLIDIFIED SLAG
SHIELDING GAS
TUBULAR ELECTRODE
POWDERED METAL, FLUX, & SLAG FORMING MATERIALS
DIRECTION OF WELDING
MOLTEN SLAG
SOLIDIFIED WELD METAL
WELD POOL
ARC & METAL TRANSFER


Electrode
Plasma gas
Shielding gas
work

e. ____________

f. ____________


TO AUTOMATIC WIRE FEED
TO WELDER POWER
TO FLUX HOPPER
CONTACT
FLUX FEED TUBE
BEAD OR FINISHED WELD METAL
SOLID SLAG
FLUX SHELF
FLUX
WELDING VEE
WELDING WIRE
BASE METAL
WORK CONNECTION
TAB
WELD BACKING PLATE
WELD TRAVEL

g. ____________

5. SAW
6. PAW
7. FCAW

Objective 13

Assignment Sheet 2—Compare Employment Opportunities in Welding

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Appropriateness of advertisements collected	______
• Neatness, appearance, and grammatical correctness of paragraph	______
• Preparation for class discussion	______

Basic Skills

Reading Writing Employability Social Studies

Directions

Collect four classified advertisements from your local or area newspaper relating to employment opportunities in the welding field. Compare each opportunity and determine which one would best suit your interests and needs. Write a paragraph on why you chose that occupation. Be prepared to discuss your paragraph in class.

Objective 23

Assignment Sheet 1—Complete the Student Safety Pledge Form

Name ______________________________ Overall Rating __________

Date ______________________________

Evaluation Criteria	Rating
• All entries completed and properly dated	______

Basic Skills

Reading

Directions

Complete the student safety pledge form and return it to the instructor.

____, who is enrolled in

Vocational ______________________________________, will as a part of his/her shop experience, operate machines, providing that the parent or guardian gives written permission.

It is important that each student be given proper instruction, both in the use of the equipment and in correct safety procedures concerning it, before being allowed to operate it. The student must assume responsibility for following safe practices, and we therefore ask that the student subscribe to the following safety pledge.

I promise to follow all safety rules for the shop.

I promise never to use a machine without first having permission from the instructor.

I will not ask permission to use a particular machine unless I have been instructed in its use, and have made 100% on the safety test for that machine.

I will report any accident or injury to the teacher immediately.

Date __________________ Student Signature ______________________

I hereby give my consent to allow my son or daughter to operate all machines and equipment necessary in carrying out the requirements of the course in which he or she is enrolled.

Date __________________ Parent's Signature ______________________

Parents are cordially invited to visit the shop to inspect the machines and to see them in operation.

Objective 24

Assignment Sheet 2—Interpret a Material Safety Data Sheet

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Directions followed	______
• All answers correct per Answers to Assignment Sheet 2	______

Basic Skills

Reading Writing Science

Directions

Review the material in Objective 6 of the information sheet, and locate and study the information presented in Student Supplement 1, "Guidelines for Interpreting Material Safety Data Sheets."

Use the MSDS at the end of this assignment sheet to answer the following questions. Write your answers on the blanks provided below each item.

MSDS Gel Graffiti®

a. What is this product used for?

____

b. What is the main ingredient in this product?

____

c. What does this product look like?

____

d. What percentage of this product is volatile (capable of exploding)?

____

e. What extinguishing agents should be used on fires created by this product?

____

f. What may happen if aerosol containers of this product are exposed to temperatures higher than 130°F?

____

g. What is the TLV for this product?

____

h. Are any of the ingredients in this product suspected of causing cancer? Explain.

____

____

____

i. What is the primary way in which this product enters the body?

____

j. What are the symptoms of overexposure to this product?

____

____

____

k. What first-aid measure should **not** be taken if this product is ingested?

____

l. What conditions should you avoid using with this product?

____

____

m. What products should you avoid using with this product?

____

____

n. How should you dispose of this product?

____

____

____

o. What special protective measures should you take when using this product?

____

____

____

p. What special hygiene precautions should you take when using this product?

____

____

JCLE035 *01/003/0020*
CLEANER, GRAFFITI GEL
3-15-89

HAZARDOUS COMMUNICATION GUIDE

Material Safety Data Sheet

N/A = Not Applicable
N/D = No Data
N/E = Not Established

Supersedes: *10/20/95*

I. General Information

Data Revised: *12/9/88*

Chemical Name & Synonyms *N/A*	Trade Name & Synonyms ***GEL GRAFFITI***
Chemical Family *Engine degreaser (gelled)*	Formula *N/A*
Proper DOT Shipping Name *Consumer commodity 48580 Sub 3*	DOT Hazard Classification *ORM-D*
Manufacturer *Crain Chemical Co., Inc.*	Manufacturer's Phone Number *214/358-3301*
Manufacturer's Address *P.O. Box 540995, Dallas, TX 75354*	Chemtrec Phone Number *1-800-424-9300*

II. Ingredients

Principal Hazardous Components	Percent	Threshold Limit Value (units)	
		OSHA	ACGIH
Ethanol *CAS# 64-17-5*	*N/A*	*1000 ppm*	*1000 ppm*
Aromatic Hydrocarbon *CAS# 64742-06-9*	*N/A*	*100 ppm*	*100 ppm*
Chlorinated Hydrocarbon *CAS# 75-09-2*	*N/A*	*500 ppm*	*500 ppm*
Glycol Ethers *CAS# 111-76-2*	*NA*	*50 ppm*	*25 ppm*

III. Physical Data

Boiling Point (°F) *N/A*	Specific Gravity ($H_2O = 1$) *N/A*
Vapor Pressure (mm Hg.) *N/D*	Percent Volatile By Volume (%) *77*
Vapor Density (Air = 1) *N/E*	Evaporation Rate (____ = 1) *N/A*
Solubility in Water *N/A*	pH *N/A*
Appearance & Odor *Opaque, white gel/characteristic odor*	

IV. Fire and Explosion Hazard Data

Flash Point (Test Method) *Flame projection 18" plus*	Auto Ignition Temperature *N/E*
Flammable Limits *Flammable*	LEL *N/E*
Extinguishing Media CO_2*, Foam*	UEL *N/E*
Special Fire Fighting Procedures *Self-contained breathing apparatus*	

Unusual Fire & Explosion Hazards
Do not expose aerosols to temperatures above 130°F or the container may rupture.

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3-15-89

HAZARDOUS COMMUNICATION GUIDE

V. Health Hazard Data

Threshold Limit Value
50 ppm

OSHA Threshold Limit Value
See Section II

ACGIH Threshold Limit Value
See Section II

Carcinogen - NTP Program
Chlorinated hydrocarbon (animal data only)

Carcinogen - IARC Program
Same as (NTP)

Symptoms of Exposure
Headaches, dizziness, irritation, burning (eyes), nausea, asphyxia and possible chemical pneumonitis if aspirated into lungs.

Medical Conditions Aggravated by Exposure
May aggravate existing eye, skin, or upper respiratory conditions.

Primary Route(s) of Entry
Inhalation

Emergency First Aid
Eyes: Flush with water for 15 minutes. If irritated, see physician. Skin: Wash with soap and water. If irritated, see physician. Inhalation: Move to fresh air. Resuscitate if necessary. Get medical aid. Ingestion: Do NOT induce vomiting. Call physician immediately.

VI. Reactivity Data

Stability		Unstable
	X	Stable
Incompatibility		
Hazardous Polymerization		May Occur
	X	Will Not Occur

Conditions to Avoid
Heat, sparks, welding arcs, open flames

Materials to Avoid
Strong oxidizing agents

Conditions to Avoid
None known

Hazardous Decomposition Products
CO_2, CO, HCL, Small amounts of phosgene and chlorine

VII. Environmental Protection Procedures

Spill Response
Absorb with suitable medium. Incinerate or land fill according to local, state, or federal regulations. Do not flush to sewer.

Waste Disposal Method
Aerosol cans, when vented to atmospheric pressure through normal use, pose no disposal hazards.

VIII. Special Protection Information

Eye Protection
Safety glasses recommended

Respiratory Protection (Specific Type)
If vapor conc. exceeds TLV, use respirator approved by U.S. Bureau of Mines for organic vapor.

Other Protection
None

Skin Protection
Neoprene gloves recommended

Ventilation Recommended
Adequate ventilation to keep vapor concentration below TLV.

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HAZARDOUS COMMUNICATION GUIDE

IX. Special Precautions

Hygienic Practices in Handling & Storage

Wash with soap and water before handling food. Do not puncture or incinerate containers. Do not store at temperatures above 130° F.

Precautions For Repair & Maintenance of Contaminated Equipment

Remove all ignition sources i.e., heat, sparks, open flames, etc.

Other Precautions

Avoid food containers. Keep out of reach of children. Remove ignition sources. Avoid breathing vapors.

Objective 25

Assignment Sheet 3—Draw a Layout of Your School Shop and Apply the Safety Color Code

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Included all required items	______
• All items correctly color-coded	______
• Layout neat and legible	______

Basic Skills

Reading Writing Critical Thinking

Directions

Review the material in Objective 7 of the information sheet.

Draw a layout of your school shop including all machines, workbenches, tools, first aid kits, and fire prevention equipment. Use the federal safety color code to identify equipment, hazards, safety features, and exposed parts that could cause accidents.

Objective 26

Assignment Sheet 4—Determine Correct Fire Extinguishers to Use for Various Situations

Name ______________________________ Overall Rating __________

Date ______________________________

Evaluation Criteria	**Rating**
• Directions followed	______
• All answers correct	______

Basic Skills

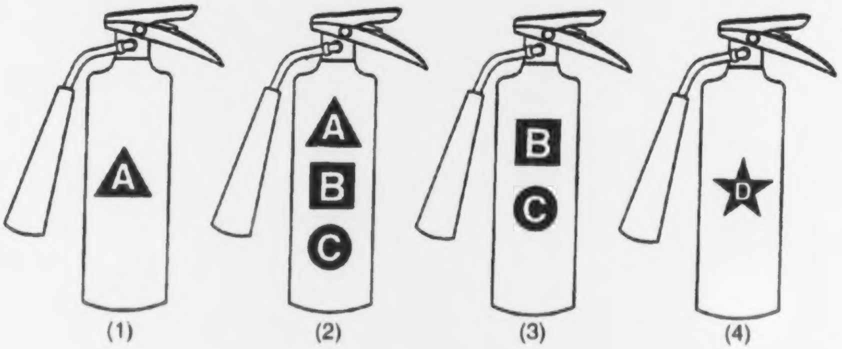
Reading Critical Thinking

Introduction

There are many fire hazards in the welding shop. These include electrical circuits, power tools, welding torches, and flammable solvents oils, and fuels. For this reason, it is very important for you to be able to correctly respond to a fire.

Directions

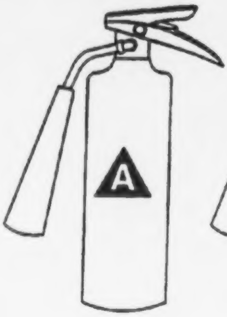
Read each of the situations given and choose the correct fire extinguisher(s) that could be used. More than one answer is possible.



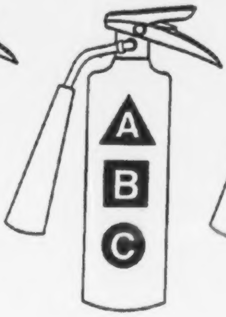
_____a. Fire in a filing cabinet containing MSDS's

_____b. Smoke coming from the electric motor of an air compressor

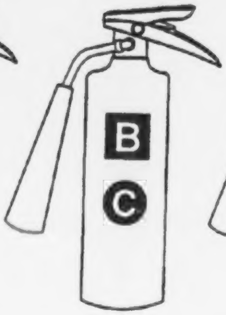
_____c. Fire caused by cigarette ashes dropping into a vat of solvent



(1)



(2)



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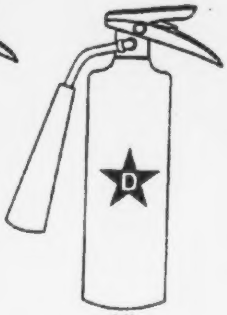


(4)

_____d. Smoke coming from a barrel of oily rags

_____e. An electrical hot plate left unattended in an office ignites papers on a bulletin board and spreads to wood paneling

_____f. Fire in an engine compartment that started because someone poured gasoline into a carburetor

_____g. Smoldering magnesium ignited by a cutting torch

_____h. Smoke coming from a portable generator

_____i. Puddle of spilled gasoline ignited by flames from a gas water heater

_____j. Smoke coming from a welding machine

Objective 27

Assignment Sheet 5—Identify and Correct Safety Violations

Name ______________________________ Overall Rating __________

Date ______________________________

Evaluation Criteria	Rating
• Five of six safety violations identified	______
• Five of six corrective measures described	______

Basic Skills

Reading Writing Critical Thinking

Directions

The following scenario relates unsafe acts that may be found in the classroom. List the safety violations and corrective measures that should have been taken to prevent them.

Scenario

The morning class was readying materials and equipment for their school project. Margarita, one of the students, went to the tool room and got the $1/2$ inch drill motor that had a red tag attached to the power cord. Margarita noticed there was a stripped wire on the drill, but she did not think it was that bad. Margarita pulled the red tag off the drill and threw it into the trash. Then she went to the workbench to find some electrical tape. The bell rang, so Margarita placed the drill with the other tools and went to catch the bus.

When the afternoon class arrived, the students finished getting the tools and materials together to begin work on the project. Lamont was assigned to use the drill on the project. He picked up the drill that Margarita had left with the other tools, and started to drill. Earlier in the day, water had been spilled on the floor and had not yet dried. While drilling, Lamont pulled the drill cord through the water and received a severe electrical shock.

a. List the safety violations.

____

____

____

____

b. List the corrective measures that should have been taken.

Objective 28

Job Sheet 1—Operate a Fire Extinguisher

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Extinguisher was carried properly	_____
• User was within stream reach of fire	_____
• P-A-S-S sequence was followed	_____
• Fire was completely extinguished	_____

Basic Skills

Reading Employability

Introduction

Using a portable fire extinguisher properly requires more than simple manipulation. You must always size up the fire and decide whether it can be extinguished with an extinguisher. If the fire is too large or too smoky, call the fire department. If the fire is small enough to be extinguished with an extinguisher, always fight it with your back to a means of escape.

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, equipment, and, materials

- Portable fire extinguisher suitable for a Class A fire
- Small Class A fire in clear, safe area
- Charged hose (hose hooked up to a water source and with water in the hose) or another secondary means of extinguishment for backup

Procedure

Caution: This procedure should only be performed outdoors on a windless day, and only under the direct supervision of your instructor.

☐ 1. Pick up the fire extinguisher by its handle.

Note: *All* modern fire extinguishers are designed to be used in an *upright* position.

☐ 2. Read the fire extinguisher label to determine proper stream reach.

Note: *Stream reach* is the distance the extinguishing agent is propelled. Stream reach varies with extinguisher, and may range from 3 to over 20 feet. Normally, the smaller the extinguisher, the shorter the stream reach.

☐ 3. Walk—do not run—to within stream reach of the fire.

☐ 4. **Pull** the pin at the top of the extinguisher that keeps the handle from being pressed.

Note: Pulling the pin automatically breaks the plastic or thin wire inspection band.

☐ 5. **Aim** the nozzle toward the fire, first releasing it from its clip if applicable.

☐ 6. **Squeeze** the discharge handle (above the carrying handle) to release the extinguishing agent.

☐ 7. **Sweep** the nozzle back and forth at the base of the flames.

☐ 8. After the fire appears to be out, probe for remaining hot spots.

☐ 9. Make sure the fire is out by extinguishing any hot spots.

Evaluator's comments: ______________________________

____

____

Objective 29

Job Sheet 2—Lift a Heavy Object Properly

Name ______________________ Overall Rating ________

Date ______________________

Evaluation Criteria	**Rating**
• Load was safely lifted	______
• Load was safely carried and set down	______

Basic Skills

Reading Employability

Introduction

The number-one worker injury in America today is back strain or injury. Most of these injuries come from trying to lift an object that is too heavy or from lifting an object improperly. It is very important, therefore, that you learn to assess the weight of a load to be lifted, and either get help to lift the load or lift the load properly, using your leg muscles, not your back.

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, equipment, and, materials

- Large, heavy box
- Gloves
- Lower-back support belt

Procedure

☐ 1. Put on gloves and lower-back support belt.

☐ 2. Size up the load.

☐ 3. Place your feet close to the object and 8 to 12 inches apart for good balance.

☐ 4. Bend your knees to a degree that is comfortable.

☐ 5. Grip the box firmly with both hands.

☐ 6. Keeping your back straight and using your leg muscles, lift the box to waist height and hold close to your body.

> **Caution:** Do not make any turning or twisting motions until the lift is complete.

☐ 7. Turn by changing foot position, making sure that your path is clear.

☐ 8. Carry the box to the new location, using a normal walking gait and keeping your view unobstructed.

☐ 9. Reverse the lifting procedure to set the box down, taking care to bend your knees, keep your back straight, and avoid setting the box on your fingers or feet.

Evaluator's comments: ______________________________

____

____

Objective 30

Job Sheet 3—Place and Climb a Ladder Safely

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Ladder was picked up correctly and safely	______
• Ladder was carried correctly and safely	______
• Ladder was placed correctly and safely (1 foot from wall for every 4 feet of ladder height; at least three rungs above work)	______
• Ladder was climbed and descended safely	______

Basic Skills

Reading Employability

Introduction

To avoid falls and strains, correct and thoughtful placement of a ladder is very important. The ladder should be lifted correctly, and placed so that its base is at least a foot from the wall for each 4 feet of height. The ladder should also be placed close enough to the work so that the user does not need to stretch to reach the work.

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, equipment, and, materials

- One 12-foot straight ladder
- Class member to heel ladder

Procedure

☐ 1. Kneel beside the ladder, facing its top at about midpoint, knee closest to ladder on the ground.

☐ 2. Reach across the ladder and grasp the rung opposite close to the far siderail.

☐ 3. Stand up—using your legs, not your back.

☐ 4. As you stand, pivot toward the other end of the ladder, slip your free arm between convenient rungs, and lift the ladder so that its top beam rests on your shoulder.

☐ 5. Carry the ladder to the work area, taking care to avoid bumping it into anything or anyone.

☐ 6. Check the work area for overhead electrical obstructions.

☐ 7. Slip the ladder from your shoulder, and rest it against the wall.

☐ 8. Adjust the ladder placement.

- ☐ a. Shoes are secure on flat surface.
- ☐ b. Base is approximately 1 foot from the wall for each 4 feet of working ladder height.
- ☐ c. Top of ladder is at least three rungs above the work.

☐ 9. Ask a classmate to heel the ladder.

☐ 10. Climb the ladder to the work.

- ☐ a. Facing the ladder.
- ☐ b. Hands on rungs or siderails.
- ☐ c. Feet squarely on rungs.

☐ 11. Descend the ladder.

- ☐ a. Facing the ladder.
- ☐ b. Hands on rungs or siderails.
- ☐ c. Feet squarely on rungs.

Evaluator's comments: ______________________________

____

____

Objective 20

Assignment Sheet 1—Determine Basic First Aid Measures for Given Emergency Situations

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Directions are followed	______
• Discussions reflect good knowledge of basic first aid measures	______

Basic Skills

Reading Critical Thinking Writing Science

Directions

Read the accident scenarios below and write the emergency and first aid actions you would take.

Scenario 1

One hot day while working in a tightly closed shop, co-worker Jane tells you that she feels dizzy and has a headache. She suddenly faints. Her skin is red, very hot, and dry. What emergency and first aid measures should you take?

Scenario 2

Co-worker Gary has been splattered with a flammable liquid, and he was burned when the liquid caught fire. The resulting burn is deep with a lot of tissue damage. Gary does not feel much pain. What emergency and first aid measures should you take?

Scenario 3

A customer was walking by some parts being uncrated when she stepped on a nail. The nail penetrated her shoe and entered her foot. There is minimal bleeding. However, she begins to complain of feeling queasy. You notice that her face is pale and her skin feels cool and clammy. Her breathing is rapid, shallow, and irregular. After a moment, she says she feels weak and wants to rest. What emergency and first aid measures should you take?

Scenario 4

Co-worker Robert was plugging a welding machine into an extension cord in the shop area of the classroom. There was a popping sound and a puff of smoke. He screamed, fell over, and lay motionless on the floor. What emergency and first aid measures should you take?

Scenario 5

Supervisor Susan is carrying a power tool when she slips and falls. She hits the workbench with her head as she falls. Her head is cut and bleeding heavily. What emergency and first aid measures should you take?

Scenario 6

During lunch, co-worker Ted begins to cough and then to choke. When you see him, he's not coughing anymore and he can't talk or breathe. What emergency and first aid measures should you take?

Scenario 7

Co-worker Lisa cuts her hand on a piece of sharp metal. She says, "It's nothing. Don't worry about me." What emergency and first aid measures should you take?

Scenario 8

Co-worker Jorge got dirt and other debris in his eye while horse playing in the shop. He's rubbing his eye, but this seems to be making it worse. What emergency and first aid measures should you take?

Scenario 9

Co-worker Angela slipped and fell from a ladder. She landed on her left arm. She says that arm really hurts and she's afraid to move it. There is no break in the skin, but the arm looks funny. What emergency and first aid measures should you take?

Scenario 10

Supervisor Steve is complaining of chest pain and indigestion. He says, "It must be something I ate." His breathing is difficult and he looks pale and worried. What emergency and first aid measures should you take?

Objective 23

Assignment Sheet 1—Identify Basic Hand Tools

Name ______________________ Overall Rating __________

Date ______________________

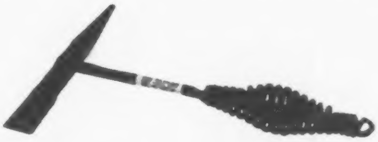
Evaluation Criteria	Rating
• Number properly identified	______

Basic Skills

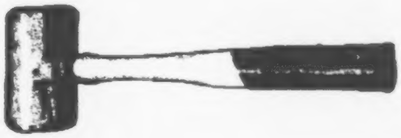
Reading Critical Thinking

Directions

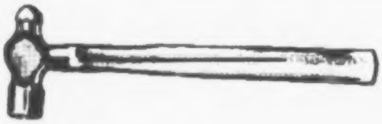
Write the name of the hand tool below its illustration.



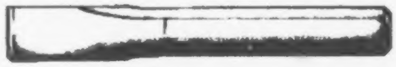
a. ______________________



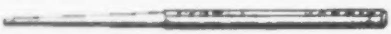
b. ______________________



c. ______________________

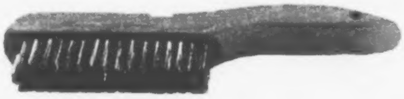


d. ______________________



e. ______________________

f. ______________________



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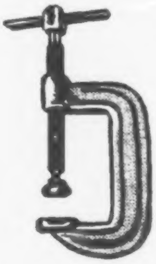
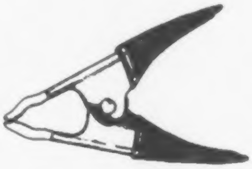
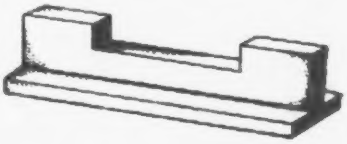


h. ______________________

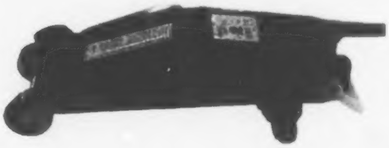


i. ______________________

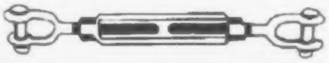
j. ______________________



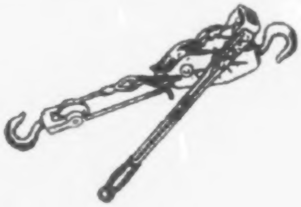
k. ______________________



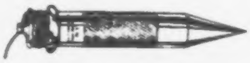
l. ______________________



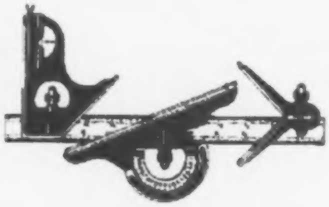
m. ______________________



n. ______________________



o. ______________________



p. ______________________

Objective 24

Assignment Sheet 2—Identify Basic Power Tools and Equipment

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Number properly identified	______

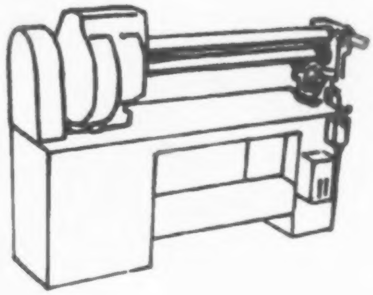
Basic Skills

Reading

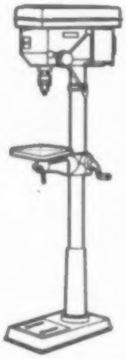
Critical Thinking

Directions

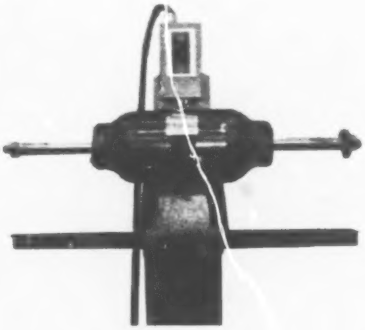
Write the name of the power tool or piece of power equipment below its illustration.



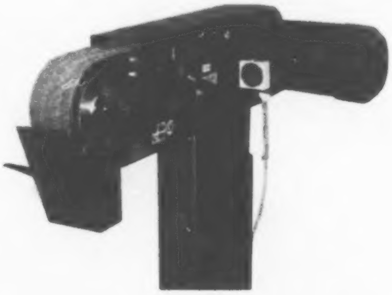
a. ______________________



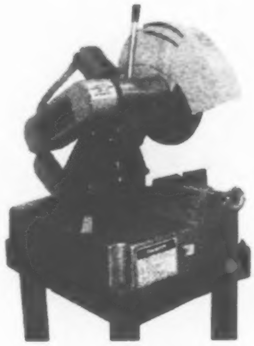
b. ______________________



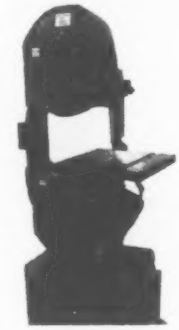
c. ______________________



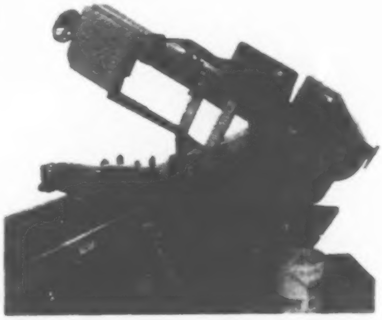
d. ______________________



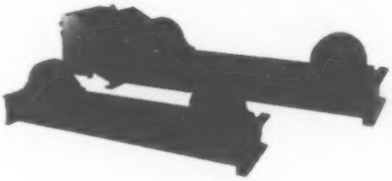
e. ______________________________



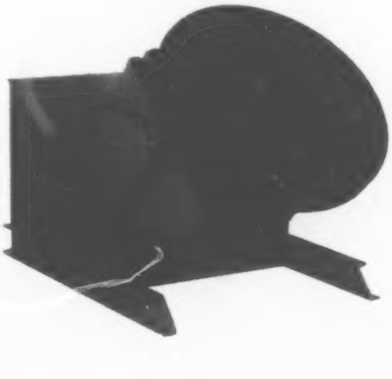
f. ______________________________



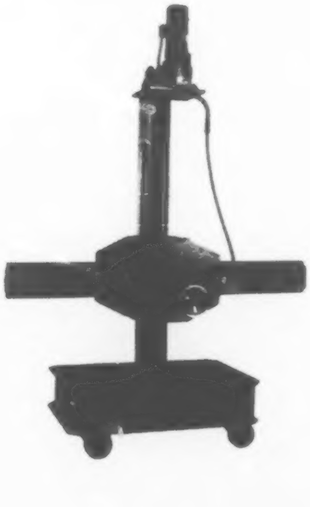
g. ______________________________



h. ______________________________



i. ______________________________



j. ______________________________

Objective 39

Assignment Sheet 1—Identify Selected Metals by Appearance, Color, and Corrosion Characteristics

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Total exact identifications	______
• Total acceptable identifications	______
• Total incorrect identifications	______
• Overall accuracy	______

Basic Skills

Reading Critical Thinking Science

Directions

Your instructor has tagged a selected group of metals with numbers. Evaluate each metal by its appearance, color, and corrosion characteristics that you can detect by visual examination. Name the exact metal if you can, but since some low- to high-carbon products may show limited differences, there may also be acceptable identifications.

Metal 1: Appearance ______________________

Color ______________________

Corrosion Characteristics: ______________________

Metal 1 Name: ______________________

Metal 2: Appearance ______________________

Color ______________________

Corrosion Characteristics: ______________________

Metal 2 Name: ______________________

Metal 3: Appearance ______________________

Color ______________________

Corrosion Characteristics: ______________________

Metal 3 Name: ______________________

Metal 4: Appearance ______________________________

Color ______________________________

Corrosion Characteristics: ______________________________

Metal 4 Name: ______________________________

Metal 5: Appearance ______________________________

Color ______________________________

Corrosion Characteristics: ______________________________

Metal 5 Name: ______________________________

Note: Your instructor may include other metals. In that case, extend your list as required.

Objective 40

Job Sheet 1—Conduct Magnet Tests to Identify Common Metals Used for Welding

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Identification of magnetic metals	______
• Identification of nonmagnetic metals	______
• Overall accuracy	______

Basic Skills

Reading Employability Science Social Studies

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, equipment, and materials

- Hand-held magnet
- Metal samples as selected and numbered by instructor
- Safety glasses
- Wooden table or nonmagnetic workspace

Procedure

☐ 1. Put on safety glasses.

☐ 2. Place metal sample 1 on a wooden or nonmagnetic workspace.

☐ 3. Place the magnet on the metal sample.

☐ 4. Lift the magnet to see if it does or does not stick to metal sample 1.

Note: Remember that a magnet will stick to ferrous metals, but will not stick to nonferrous metals.

☐ 5. Stop and record your findings on the Magnet Test Chart that accompanies this job sheet.

☐ 6. Repeat the procedure for each of the metal samples.

☐ 7. Complete your Magnet Test Chart and turn it in to your instructor for evaluation.

☐ 8. Clean up work area and return tools and materials to proper storage.

Metal Sample #	Magnetic (Ferrous)	Nonmagnetic (Nonferrous)
1		
2		
3		
4		
5		

Evaluator's Comments: ____________________

____

____

Objective 41

Job Sheet 2—Conduct Chisel Tests to Identify Common Metals Used for Welding

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	**Rating**
• Total correct identifications	______
• Total incorrect identifications	______
• Overall accuracy	______

Basic Skills

Reading Employability Science Social Studies

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, equipment, and materials

- Cold chisel
- Hammer
- Metal samples as selected and numbered by instructor
- Safety glasses
- Vise

Procedure

☐ 1. Put on safety glasses.

☐ 2. Secure metal sample 1 in a vise.

☐ 3. Select a starting point that will provide a sufficient working distance along the sample.

☐ 4. Place the chisel at a 30° to 40° angle over the workpiece and strike the chisel head firmly with a hammer.

Note: Remember to listen for characteristic sounds as you conduct each test.

☐ 5. Strike the chisel as many times as required to establish whether it's easy or difficult to chip the metal, and record the information on the Chisel Test Chart that accompanies this job sheet.

☐ 6. Determine whether the chips (or chip) have smooth or rough edges, and record the information on the Chisel Test Chart.

☐ 7. Repeat the procedure for all metal samples.

☐ 8. Complete the Chisel Test Chart and turn it in to your instructor for evaluation.

☐ 9. Clean up area and return tools and materials to proper storage.

Metal Sample #	Degree of Chipping Difficulty	Size of Chips	Appearance of Chips	Type or Name of Metal
1				
2				
3				
4				
5				

Evaluator's Comments: ______________________________

____

____

Objective 42

Job Sheet 3—Conduct Spark Tests to Identify Common Metals Used for Welding

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Total correct identifications	______
• Total incorrect identifications	______
• Overall accuracy	______

Basic Skills

Reading Employability Science Social Studies

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, equipment, and materials

- Locking pliers
- Metal samples selected and numbered by instructor
- Safety glasses and face shield
- Stationary or portable grinder
- Wire brush

Procedure

☐ 1. Check the work area to make sure flying sparks will not create an unsafe condition.

☐ 2. Put on safety glasses and face shield.

☐ 3. Check grinder for the proper surface feet per minute of the grinding wheel or disc.

Note: Check with your instructor if you need help checking the rpm.

☐ 4. Clean the grinding wheel with a wire brush, if required.

☐ 5. Move light colored materials away from the grinder in order to create as dark a background as possible for the spark test.

☐ 6. Turn off the light on the grinder, if there is one.

☐ 7. Lock pliers onto metal sample 1, or put the sample in a vise.

☐ 8. Turn grinder on and allow it to reach maximum rpm.

☐ 9. Position yourself at the grinder so that all sparks will be free of obstructions and easy to see.

☐ 10. Place metal sample 1 on the tool rest, hold pliers tightly, and move metal into the grinding wheel until it makes light contact.

☐ 11. Grind metal hard enough and long enough to produce a stable spark pattern.

☐ 12. Observe the color close to the wheel, and the color of the sparks at the dying end of the spark stream.

☐ 13. Observe the shape of the spark pattern or stream pattern.

☐ 14. Observe the volume and length of the spark stream.

☐ 15. Turn stationary or portable grinder off.

☐ 16. Remove metal sample 1.

☐ 17. Record your observations about metal sample 1 on the Spark Identification Chart that accompanies this job sheet.

☐ 18. Repeat the spark testing procedure in order for the remaining number of samples your instructor has selected.

☐ 19. Record your observations for each metal tested.

☐ 20. Complete your Spark Identification Chart and turn it in to your instructor for evaluation.

☐ 21. Clean up area and return tools and materials to proper storage.

Metal Sample #	Color	Pattern Shape	Volume	Length in Inches	Name of Metal
1	At wheel: End Stream:				
2	At wheel: End Stream:				
3	At wheel: End Stream:				
4	At wheel: End Stream:				
5	At wheel: End Stream:				

Evaluator's Comments: ____________________

____

____

Objective 15

Assignment Sheet 1—Add, Subtract, Multiply, and Divide Fractions

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	**Rating**
• Accuracy in adding	______
• Accuracy in subtracting	______
• Accuracy in multiplying	______
• Accuracy in dividing	______

Basic Skills

Reading Mathematics

Directions

Review the following procedures for working with fractions, and then complete the problems that follow.

1. To add fractions:

   a. Change all fractions to a common denominator.

   b. Change all mixed numbers to improper fractions.

   c. Add all the numerators.

   d. Write down the total fraction.

   e. Reduce fraction to lowest terms in final form.

   f. If fraction totals to an improper fraction, simplify and reduce to lowest terms.

   Example 1:

   Add: $^1/_8 + {}^1/_{16} + {}^3/_4 + {}^1/_{16} = {}^2/_{16} + {}^1/_{16} + {}^{12}/_{16} + {}^1/_{16}$

   Change to largest common denominator.

   $^2/_{16} + {}^1/_{16} + {}^{12}/_{16} + {}^1/_{16} = {}^{16}/_{16} = 1$

   Add numerators, place over common denominator, and reduce to lowest terms.

Example 2:

Add: $^{3}/_{8} + ^{1}/_{2} + ^{5}/_{8} + ^{3}/_{4} = ^{3}/_{8} + ^{4}/_{8} + ^{5}/_{8} + ^{6}/_{8}$

Change to largest common denominator.

$^{3}/_{8} + ^{4}/_{8} + ^{5}/_{8} + ^{6}/_{8} = ^{18}/_{8} = 2^{2}/_{8} = 2^{1}/_{4}$

Add numerators, place over common denominator, change from improper fraction to proper fraction, and reduce to lowest terms.

2. To subtract fractions:

   a. Change all fractions to a common denominator.

   b. Change all mixed numbers to improper fractions.

   c. Subtract the numerators.

   d. Write down the remaining fraction.

   e. Reduce fraction to lowest terms in final form.

   f. If fraction totals to an improper fraction, simplify and reduce to lowest terms.

Example 3:

Subtract: $^{7}/_{8} - ^{9}/_{16} = ^{14}/_{16} - ^{9}/_{16} = ^{5}/_{16}$

Change to largest common denominator, subtract numerators, complete answer.

Example 4:

Subtract: $1^{3}/_{16} - ^{1}/_{4} = ^{19}/_{16} - ^{4}/_{16} = ^{15}/_{16}$

Change mixed number to improper fraction; change fractions to largest common denominator; subtract numerators; complete answer.

Example 5:

Subtract: $2^{3}/_{8} - 1^{5}/_{32} = ^{19}/_{8} - ^{37}/_{32} = ^{76}/_{32} - ^{37}/_{32} = ^{39}/_{32} = 1^{7}/_{32}$

Change mixed numbers to improper fraction; change fractions to largest common denominator; subtract numerators; change improper fraction to proper fraction; complete answer.

3. To multiply fractions:

   a. Multiply numerators.

   b. Multiply denominators.

   c. Write down new numerator over new denominator.

   d. Reduce fraction to lowest terms.

   e. Is using mixed numbers, change fraction to improper fraction, multiply numerator and denominator, change to a mixed number, reduce fraction remainder to lowest terms.

Example 6:

Multiply: $\frac{5}{8} \times \frac{1}{2} \quad \frac{5 \times 1}{8 \times 2} = \frac{5}{16}$

Multiply numerator, multiply denominator, complete answer.

Example 7:

$$\frac{3}{4} \times 6 = \frac{3}{4} \times \frac{6}{1} = \frac{3 \times 6}{4 \times 1} = \frac{18}{4} = 4\frac{2}{4} = 4\frac{1}{2}$$

Multiply numerator by the whole number; multiply denominator by one; reduce to proper fraction; reduce to lowest terms; complete answer.

Example 8:

$$23\frac{7}{16} \times 4 = (23 \times 4) + (\frac{7}{16} \times 4) = (92) + (\frac{7 \times 4}{16 \times 1}) = (92) + (\frac{28}{16}) = (92)$$

$$+ (1\frac{12}{16}) = (92) + (1\frac{3}{4}) = 93\frac{3}{4}$$

Multiply whole number of mixed number by whole number; multiply fractional part of mixed number numerator and denominator by whole number; reduce fractional part of mixed number to proper fraction and lowest terms; add whole numbers of each part; complete answer.

Example 9:

$$1\frac{3}{4} \times 4\frac{3}{8} = \frac{7}{4} \times \frac{35}{8} = \frac{245}{32} = 7\frac{21}{32}$$

Change mixed numbers to improper fractions; multiply numerators and denominators; change improper fraction to proper fraction; complete answer.

4. To multiply fractions with the cancellation method:

   a. Extend the fractions on a common line.

   b. Cancel corresponding factors above and below the line.

   c. Multiply canceled fractions.

   Example 10:

$$\frac{1}{2} \times \frac{4}{5} = \frac{1}{\underset{1}{\cancel{2}}} \times \frac{\overset{2}{\cancel{4}}}{5} = \frac{2}{5}$$

   The fraction is reduced before multiplying and this helps avoid the use of larger numbers. Since 2 is a factor of 4, numerators and denominators of the fractions can be reduced by cancellation and make the problem easier to work.

5. To divide fractions:

   a. Express fraction in division form.

   b. Invert numerator and denominator of dividing fraction.

   c. Multiply numerators and denominators.

   d. Reduce fractions to lowest terms.

   e. If answer is an improper fraction, change to proper fraction, and reduce to lowest terms.

   Example 11:

$$\frac{7}{8} \div \frac{1}{2} = \frac{\frac{7}{8}}{\frac{1}{2}} = \frac{7}{8} \times \frac{2}{1} = \frac{14}{8} = \frac{7}{4} = 1\frac{3}{4}$$

   Write fraction in division form; invert division fraction; multiply numerators and denominators; change fraction from improper to proper fraction; reduce to lowest terms; complete answer.

   Example 12:

$$2\frac{1}{4} \div 1\frac{1}{8} \text{ or } \frac{2\frac{1}{4}}{1\frac{1}{8}} = \frac{\frac{9}{4}}{\frac{9}{8}} = \frac{9}{4} \times \frac{8}{9} = \frac{72}{36} = 2$$

6. Problems

a. Add the following:

1. $^{1}/_{2} + ^{3}/_{4} =$ ________________
2. $^{3}/_{4} + ^{5}/_{8} + ^{9}/_{16} + ^{5}/_{32} =$ ________________
3. $2^{1}/_{2} + 3^{3}/_{4} + 5^{5}/_{8} + ^{3}/_{8} =$ ________________

b. Subtract the following:

1. $^{7}/_{8} - ^{3}/_{4} =$ ________________
2. $1^{9}/_{16} - ^{3}/_{4} =$ ________________
3. $3^{3}/_{8} + 1^{9}/_{16} =$ ________________

c. Multiply the following:

1. $^{5}/_{8} \times ^{3}/_{4} =$ ________________
2. $5^{5}/_{16} \times 4 =$ ________________

d. Divide the following:

1. $^{3}/_{4} \div ^{3}/_{8} =$ ________________
2. $2^{1}/_{2} \div 5 =$ ________________

Objective 16

Assignment Sheet 2—Add, Subtract, Multiply, and Divide Decimal Equivalents

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Accuracy in adding	______
• Accuracy in subtracting	______
• Accuracy in multiplying	______
• Accuracy in dividing	______

Basic Skills

Reading Mathematics

Directions

Review the following procedures for working with decimal equivalents, and then complete the problems that follow.

1. To work decimal equivalents:

   a. Write first decimal number.

   b. Write second decimal number under first decimal number.

   Note: Decimal points must be in line.

   c. If there are more than two decimal numbers, continue to list each in column order keeping the decimal points in line.

   d. Complete answer.

   e. Place decimal point in proper position for final answer.

2. To add decimals:

Example 1:

$$\begin{array}{r} 0.9375 \\ \underline{+0.5250} \\ 1.4625 \end{array}$$

3. To subtract decimals:

Example 2:

$$\begin{array}{r} 0.3857 \\ \underline{-0.0125} \\ 0.3732 \end{array}$$

4. To multiply decimals:

Example 3:

$$\begin{array}{r} 0.2343 \\ \underline{\times 5} \\ 1.1715 \end{array}$$

Note: Count over four decimals on completed answer for correct decimal positioning.

5. To divide decimals:

Example 4:

$$2.3865 \div 3 = \begin{array}{r} 0.7955 \\ 3\overline{)2.3865} \\ \underline{2\,1} \\ 28 \\ \underline{27} \\ 16 \\ \underline{15} \\ 15 \\ \underline{15} \end{array}$$

Note: Indicate whole unit as zero or whole number before the decimal.

6. Problems

a. Add the following decimal equivalents:

1. 2.125 + 2.375 + 4.0625 + 9.0008 + 0.12 = ______________
2. 0.046 + 0.00002 + 0.653 + 8.1673 = ______________
3. 0.5000 + 0.015 + 0.171 + 8.7003 + 16.37 = ______________

b. Subtract the following decimal equivalents:

1. 8.763 – 0.041 = ______________
2. 126.373 – 126.219 = ______________
3. 9 – 0.125 = ______________

   Note: 9 = 9.000

c. Multiply the following decimal equivalents:

1. 0.9321 x 1.76 = ____________
2. 9.429 x 8.670 = ____________

d. Divide the following decimal equivalents:

1. 0.0672 ÷ 28 = ____________
2. 73.16 ÷ 24 = ____________

Objective 17

Assignment Sheet 3—Convert Fractions to Decimal Form, Change Fractions to a Common Denominator, and Reduce Fractions to Lowest Terms

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Accuracy with conversion	______
• Accuracy with common denominator	______
• Accuracy with reduction to lowest terms	______

Basic Skills

Reading Mathematics

Directions

Review the following procedures for converting fractions to decimal form, changing fractions to a common denominator, and reducing fractions to lowest terms, then complete the problems that follow.

1. To convert fractions to decimal form:

Example 1:

$$\begin{array}{l} \quad\quad\;\; 0.500 \\ {}^1/_2 = 2\overline{)1.000} = 0.500 \\ \quad\quad\;\; 1.000 \end{array}$$

Example 2:

$$\begin{array}{l} \quad\quad\;\; 0.750 \\ {}^3/_4 = 4\overline{)3.000} = 0.750 \\ \quad\quad\;\; \underline{28} \\ \quad\quad\;\;\; 20 \\ \quad\quad\;\;\; \underline{20} \\ \quad\quad\;\;\;\; 0 \end{array}$$

Divide the denominator into the numerator; place the decimal in the correct position; use quotient as the answer.

2. To change fractions to a common denominator:

Example 3:

$$\frac{1}{2}+\frac{1}{4}+\frac{5}{8}=\frac{1\times 4}{2\times 4}+\frac{1\times 2}{4\times 2}+\frac{5}{8}=\frac{4}{8}+\frac{2}{8}+\frac{5}{8}=\frac{11}{8}=1\frac{3}{8}$$

Example 4:

$$\frac{1}{16}+\frac{3}{32}+\frac{5}{64}+\frac{3}{4}=\frac{1\times 4}{16\times 4}+\frac{3\times 2}{32\times 2}+\frac{5}{64}+\frac{3\times 16}{4\times 16}=\frac{4}{64}+\frac{6}{64}+\frac{5}{64}+\frac{48}{64}=\frac{63}{64}$$

Using the largest denominator, place all fractions in the same base by multiplying both numerator and denominator by same base power; add all numerators; complete answer.

Note: Above examples did not have to be reduced to lowest terms, but Example 3 had to be changed from an improper to a proper fraction.

3. Reducing fractions to lowest terms—Divide the numerator and denominator by the largest whole number that will go into each evenly.

Example 5: Reduce $^4/_{16}$ to its lowest terms.

$$\frac{4}{16}=\frac{4\quad 4}{16\quad 4}=\frac{1}{4}$$

A fraction is in its lowest terms when numerator and denominator are divided by the greatest factor common to both.

Note: The fraction 1/4 is reduced to its lowest term because the numerator (1) and the denominator (4) cannot be divided by the same number.

4. Problems

a. Convert the following fractions to decimal form. Show all work.

1. $^{1}/_{2}$ = ________________
2. $^{5}/_{8}$ = ________________
3. $^{1}/_{4}$ = ________________
4. $^{1}/_{8}$ = ________________
5. $^{5}/_{16}$ = ________________
6. $^{9}/_{16}$ = ________________
7. $^{3}/_{4}$ = ________________
8. $^{7}/_{8}$ = ________________
9. $^{3}/_{8}$ = ________________
10. $^{11}/_{16}$ = ________________

b. Change the following fractions to a common denominator and solve.

1. $^{1}/_{8} + ^{1}/_{4}$ = ________________
2. $^{1}/_{16} + ^{5}/_{32} + ^{3}/_{8}$ = ________________
3. $^{7}/_{8} + ^{9}/_{16} + 1^{1}/_{8} + ^{5}/_{32}$ = ________________
4. $^{15}/_{64} - ^{1}/_{8}$ = ________________
5. $^{7}/_{64} + ^{11}/_{16} + ^{9}/_{64} + ^{1}/_{8} + ^{7}/_{16} + ^{1}/_{4} + ^{3}/_{32}$ = ________________

c. Reduce the following fractions to lowest terms.

1. $^{12}/_{16}$ = ________________
2. $^{16}/_{24}$ = ________________
3. $^{48}/_{64}$ = ________________
4. $^{25}/_{75}$ = ________________
5. $^{22}/_{64}$ = ________________
6. $^{72}/_{128}$ = ________________
7. $^{63}/_{56}$ = ________________
8. $^{500}/_{800}$ = ________________
9. $^{57}/_{48}$ = ________________
10. $^{150}/_{200}$ = ________________

Note: Change improper fractions to proper form; then reduce to lowest terms.

Objective 18

Assignment Sheet 4—Write Fractions as Decimals and Percents

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Accuracy with fractions as decimals	______
• Accuracy with fractions as percents	______

Basic Skills

Reading

Mathematics

Directions

Review the following procedures for writing fractions as decimals and percents, and then complete the problems that follow.

1. Expressing fractions as decimals; divide the numerator by the denominator.

Example 1:

$$\frac{5}{8} \qquad \begin{array}{r} .625 \\ 8\overline{)5.000} \\ \underline{4\,8} \\ 20 \\ \underline{16} \\ 40 \\ \underline{40} \end{array}$$

2. Expressing fractions as percents:

   a. Express the fraction in decimal form.

   b. Move the decimal point two places to the right.

c. Place the % symbol after the number.

Example 2:

$$\frac{7}{33} \qquad \begin{array}{r} .2121 = 21.21\% \\ 33\overline{)7.0000} \\ \underline{66} \\ 40 \\ \underline{33} \\ 70 \\ \underline{66} \\ 40 \\ \underline{33} \\ 7 \end{array}$$

Note: Percent means that some number is being compared to 100.

d. Multiply the numerator and denominator by that number which will change the denominator to 100.

e. Drop the denominator.

f. Add the % symbol.

Example 3:

$$\frac{3}{4} = \frac{3}{4} \times \frac{25}{25} = \frac{75}{100} = 75\%$$

3. Problems

a. Express each fraction as a decimal.

1. 1/8 = ____________________
2. 1/4 = ____________________
3. 1/2 = ____________________
4. 3/4 = ____________________
5. 5/8 = ____________________
6. 7/20 = ____________________
7. 7/16 = ____________________
8. 1/9 = ____________________
9. 4/9 = ____________________
10. 4/5 = ____________________

b. Express each fraction as a percent.

1. $^1/_4$ = ____________________
2. $^2/_9$ = ____________________
3. $^7/_{10}$ = ____________________
4. $^3/_4$ = ____________________
5. $^2/_2$ = ____________________
6. $^9/_{11}$ = ____________________
7. $^1/_3$ = ____________________
8. $^4/_9$ = ____________________
9. $^2/_6$ = ____________________
10. $^5/_8$ = ____________________

Objective 19

Assignment Sheet 5—Write Percents as Fractions and Decimals

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	**Rating**
• Accuracy with percents as fractions	______
• Accuracy with percents as decimals	______

Basic Skills

Reading Mathematics

Directions

Review the following procedures for writing percents as fractions and decimals, and then complete the problems that follow.

1. Expressing percents as fractions:

   a. Drop the percent symbol.

   b. Place the number over 100.

   Note: Reduce to simplest form.

   Example 1:

   $38\% = \frac{38}{100} = \frac{19}{50}$

2. Expressing percents as decimals:

   a. Drop the percent symbol.

   b. Move the decimal point two places to the left.

   Example 2:

   $75\% = .75$ and $33^{1}/_{3}\% = .333$

3. Problems

a. Express each percent as a fraction.

1. 50% = ______________________
2. 25% = ______________________
3. $33\frac{1}{3}$% = ______________________
4. 36% = ______________________
5. 28% = ______________________
6. $14\frac{2}{7}$% = ______________________
7. 21% = ______________________
8. 45% = ______________________
9. $66\frac{2}{3}$% = ______________________
10. 70% = ______________________

b. Express each percent as a decimal.

1. 47% = ______________________
2. 15% = ______________________
3. 33.3% = ______________________
4. 62% = ______________________
5. 75% = ______________________
6. 3% = ______________________
7. 16.8% = ______________________
8. 9% = ______________________
9. 10% = ______________________
10. 50% = ______________________

Objective 20

Assignment Sheet 6—Write Decimals as Fractions and Percents

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	**Rating**
• Accuracy with decimals as fractions	______
• Accuracy with decimals as percents	______

Basic Skills

Reading Mathematics

Directions

Review the following procedures for writing decimals as fractions and percents, and then complete the problems that follow.

1. Expressing decimals as fractions:

   a. If there is one decimal place, drop the decimal point and place the number over 10.

      Example 1:

      $.4 = \frac{4}{10} = \frac{2}{5}$

   b. If there are two decimal places, drop the decimal point and place the number over 100.

      Example 2:

      $.75 = \frac{75}{100} = \frac{3}{4}$

   c. If there are three decimal places, drop the decimal point and place the number over 1000.

      Example 3:

      $.375 = \frac{375}{1000} = \frac{3}{8}$

      Note: Do not forget to reduce to simplest form.

2. Expressing decimals as percents:

   a. Move the decimal point two places to the right.

   b. Place the percent symbol after the number.

   Example 3:

   4 = 400%
   .37 = 37%

3. Problems

   a. Express each decimal as a fraction.

      1. .5 ______________________
      2. .8 ______________________
      3. .7 ______________________
      4. .25 ______________________
      5. .68 ______________________
      6. .55 ______________________
      7. .94 ______________________
      8. .375 ______________________
      9. .875 ______________________
      10. .212 ______________________

   b. Express each decimal as a percent.

      1. .12 ______________________
      2. .19 ______________________
      3. .7 ______________________
      4. .29 ______________________
      5. .37 ______________________
      6. .42 ______________________
      7. .5 ______________________
      8. .523 ______________________
      9. .746 ______________________
      10. 3.75 ______________________

Objective 21

Assignment Sheet 7—Make Conversions with a Decimal Equivalent Chart

Name ____________________ Overall Rating __________

Date ____________________

Evaluation Criteria	Rating
• Accuracy with decimals equivalents	______
• Accuracy with fractional equivalents	______

Basic Skills

Reading Mathematics

Directions

Review the following procedures for writing fractions as decimal equivalents and writing decimal equivalents as fractions, and then complete the problems that follow.

1. Observe the order of fraction listings from small to large sizes on the decimal equivalent chart.

   Note: If using a chart other than the one provided, ask the instructor to explain the chart.

2. Observe the order of decimal listings from small to large sizes.
3. Locate a fractional size and then locate the decimal equivalent directly to the right (usually connected by a bar or line).
4. Using reverse order in step 3, locate the decimal equivalent and read the fractional size directly to the left (usually connected by a bar or line).

5. Problems

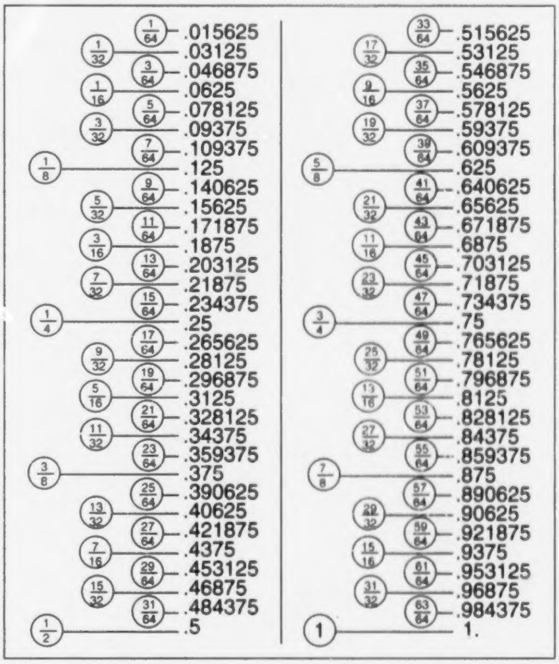
Note: Be sure to reference the Decimal Equivalent Chart that accompanies this assignment sheet.

a. Locate and list the decimal equivalent for the fractional sizes listed below:

1. 1/16 = ______________________________
2. 7/8 = ______________________________
3. 1/4 = ______________________________
4. 1/2 = ______________________________
5. 9/16 = ______________________________

b. Locate and list the fractional size for the decimal equivalents listed below:

1. 0.4375 = __________________________
2. 0.3125 = __________________________
3. 0.375 = __________________________
4. 0.125 = __________________________
5. .6875 = __________________________



1/64	.015625	33/64	.515625
1/32	.03125	17/32	.53125
3/64	.046875	35/64	.546875
1/16	.0625	9/16	.5625
5/64	.078125	37/64	.578125
3/32	.09375	19/32	.59375
7/64	.109375	39/64	.609375
1/8	.125	5/8	.625
9/64	.140625	41/64	.640625
5/32	.15625	21/32	.65625
11/64	.171875	43/64	.671875
3/16	.1875	11/16	.6875
13/64	.203125	45/64	.703125
7/32	.21875	23/32	.71875
15/64	.234375	47/64	.734375
1/4	.25	3/4	.75
17/64	.265625	49/64	.765625
9/32	.28125	25/32	.78125
19/64	.296875	51/64	.796875
5/16	.3125	13/16	.8125
21/64	.328125	53/64	.828125
11/32	.34375	27/32	.84375
23/64	.359375	55/64	.859375
3/8	.375	7/8	.875
25/64	.390625	57/64	.890625
13/32	.40625	29/32	.90625
27/64	.421875	59/64	.921875
7/16	.4375	15/16	.9375
29/64	.453125	61/64	.953125
15/32	.46875	31/32	.96875
31/64	.484375	63/64	.984375
1/2	.5	1	1.

Objective 22

Assignment Sheet 8—Make Conversions with an Inches-to-Decimal Conversion Chart

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	**Rating**
• Accuracy with feet and inches to decimals	______
• Accuracy with decimals to feet and inches	______

Basic Skills

Reading Mathematics

Directions

Review the following procedures for converting feet and inches to decimals and converting decimals to feet and inches. Then complete the problems that follow.

1. Converting feet and inches to decimals:

   a. Determine total number of full feet and multiply by 1.000.

      Example 1:

      To convert $5'7^{1}/_{2}''$ to decimals, first multiply 5 x 1.000 = 5.000

   b. Determine total number of full inches and divide by 12, and add to total number of full feet.

      Example 2:

      In converting $5'7^{1}/_{2}''$ to decimals, first multiply the 5′ by 1.000 = 5.000, then divide 7 by 12,

```
      .5833
  12)7.000
     6 00
     1 00
       96
       40
        36
        40
```

      then add .5833 to 5.000 = 5.5833

      Note: Be sure to reference the Inches-to-Decimal Chart that accompanies this assignment sheet.

c. Determine fractions of inches in the measurement, divide the numerator (top number) by the denominator (bottom number), then divide that total by 12, and add this figure to the full feet and full inches.

Example 3:

The fractional $^1/_2$" converts to a decimal by dividing 1 by 2,

```
   .5000
2 )1.000
   1 0
   ---
    000
```

and then dividing .5000 by 12,

```
    .0417 (round off to 7)
12 ).5000
     4 8
     ---
      20
      12
      --
       80
       84
```

and add the .0417 to 5.5833

```
                        5.5833
                         .0417
                        5.6250
```

which makes 5.6250 the decimal conversion of 5′ 7$^1/_2$″

2. Converting decimals to feet and inches:

a. Convert the decimal figure to the left of the decimal point into full feet.

Example: In the decimal measurement 5.6250′, the 5 to the left of the decimal = 5′

b. Convert the decimal figure to the right of the decimal point into full inches by multiplying by 12.

Example:

```
  .6250
 x  12
 ------
 1.2500
 6.250
 ------
 7.5000
```

c. Convert the decimal figure to the left of the decimal point into full inches.

Example: In the decimal measurement 7.500, the 7 to the left of the decimal = 7″

d. Convert the remaining decimal figure to fractions of an inch by multiplying by 1.000 and reducing it to its lowest terms.

Example: When the decimal measurement .5000 is multiplied by 1.000, the result is 5, so to convert this, drop the decimal point and place the figure over 10 to get $^5/_{10}$, then reduce this figure to its lowest terms to get $^1/_2$" so that the decimal measurement of 5.6250 = 5 7$^1/_2$"

3. Problems

Note: Be sure to follow rules for rounding off figures.

a. Convert the following feet and inches to decimals.

1. 9′ 6$^3/_4$″ = ____________________
2. 3′ 4$^5/_8$″ = ____________________
3. 14′ 2$^1/_4$″ = ____________________
4. 1′ 6″ = ____________________

b. Convert the following decimals to feet and inches.

1. 2.5000′ = ____________________
2. 8.6333′ = ____________________
3. 11.7425′ = ____________________
4. 17.1125′ = ____________________

Inches-to-Decimal Conversion chart

1/16″	.0052	1″	.0833
3/32″	.0078	2″	.1667
1/8″	.0104	3″	.2500
5/32″	.0130	4″	.3333
3/16″	.0156	5″	.4167
7/32″	.0182	6″	.5000
1/4″	.0208	7″	.5833
9/32″	.0234	8″	.6667
5/16″	.0260	9″	.7500
3/8″	.0313	10″	.8333
7/16″	.0364	11″	.9167
1/2″	.0417	12″	1.0000
9/16″	.0468		
5/8″	.0521		
11/16″	.0572		
3/4″	.0625		
13/16″	.0677		
7/8″	.0726		
15/16″	.0781		

Objective 23

Assignment Sheet 9—Measure Distances with 1″, 1/2″, and 1/4″ Graduations

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Accuracy with 1″ graduations	______
• Accuracy with 1/2″ graduations	______
• Accuracy with 1/4″ graduations	______

Basic Skills

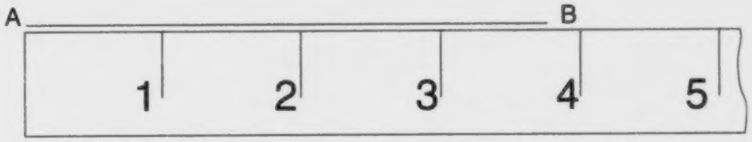
Reading Mathematics

Directions

Study the rules in the illustrations and answer the questions about the graduations on each set of rules.

1. Converting feet and inches to decimals:

   a. Point A, on line segment AB below, is at the end of the rule. Point B is nearest what number? ______________________



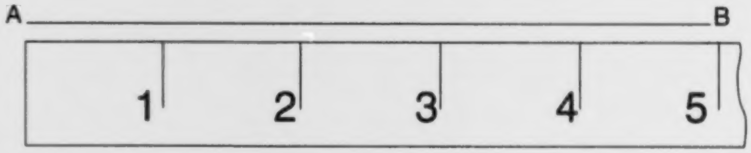
   b. Is AB exactly 4 inches long? ____________

   c. Is AB exactly 3 inches long? ____________

   d. AB is approximately ____________ inches in length.

   e. Would a measurement less than a full inch be exact on this rule? _________

2. a. Is AB below exactly 5 inches long? ______________



b. Is the measure of AB closer to 4 inches or 5 inches? ________

c. Can this rule normally be used to measure with complete accuracy? ________

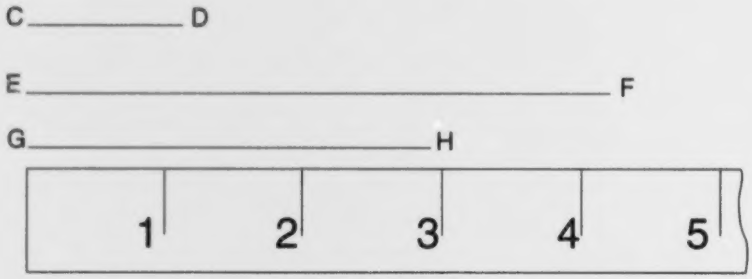
d. Always measure to the ________ ________ marked on the ruler.

3. On the rule below, give the measure of each line segment to the nearest mark. Label your answers with the correct unit of measure.

a. CD = ________

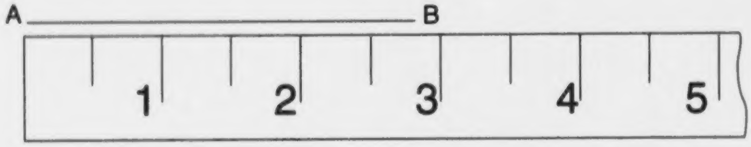
b. EF = ________

c. GH = ________



d. Are the measurements above exact or approximate? ________

4.

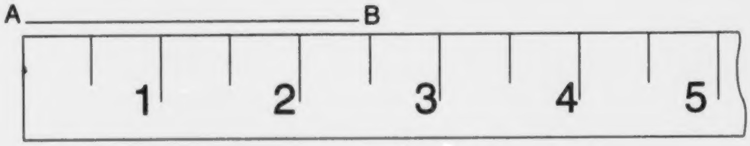


a. Is 3 inches an accurate measure for AB above? ________

b. Could we get a more accurate measure of AB if we divided the inches into smaller units? ________

5. a. Into how many parts has each inch been divided on the rule below?

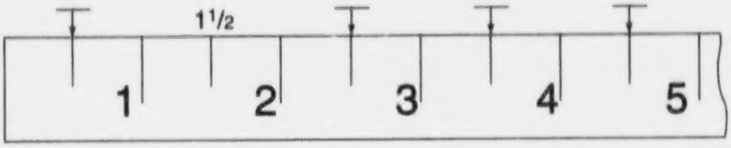
____



b. Is B located nearer 2, $2\frac{1}{2}$, or 3 inches? ________

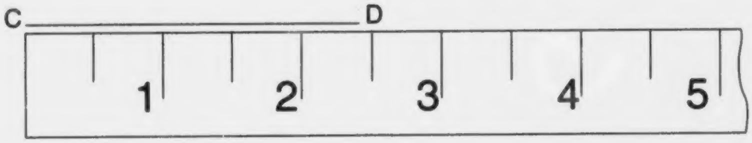
Note: Remember, always read to the nearest mark on a rule.

6. Write in the missing numbers.



7. a. Is point D below nearer 2 or $2\frac{1}{2}$? ________

b. Therefore, using this rule, the measure of CD is approximately ________ inches.

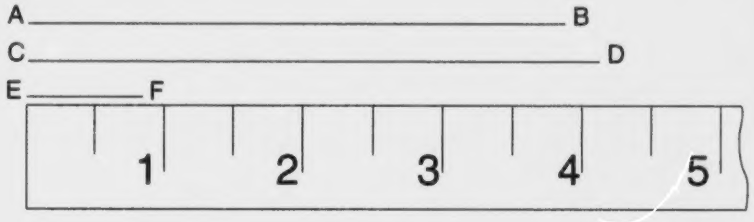


8. To measure a line segment, line up one of its end points with the end of the rule. Give the approximate measure of each segment shown below.

a. AB = ____________

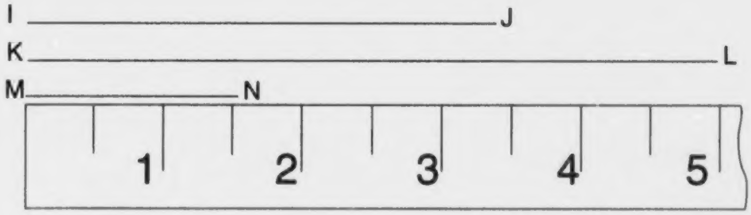
b. CD = ____________

c. EF = ____________



d. Although the measures given above are correct, are they exact? ________

9. Give the measure of each line segment below:



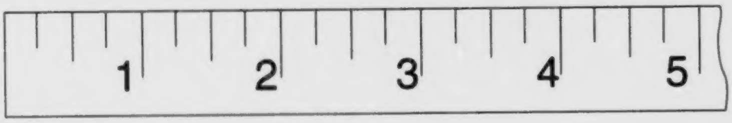
a. IJ = ____________

b. KL = ____________

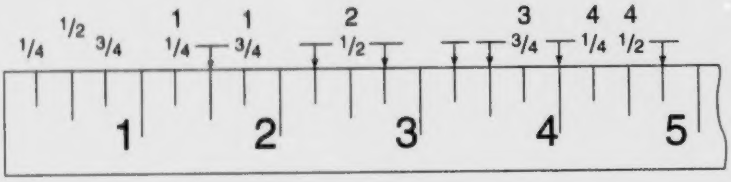
c. MN = ____________

10. a. To get a still more accurate measurement, divide 1/2-inches into two smaller units. Since 1/2 ÷ 2 = 1/4, the new marks would be ________________ of an inch apart.

b. Each inch on the rule below is divided in how many parts? ___________



11. Fill in the missing numbers


1/4
1/2
3/4
1 1/4
1 3/4
2 1/2
3 3/4
4 1/4
4 1/2
1
2
3
4
5

Objective 24

Assignment Sheet 10—Measure Distances with $^{1}/_{4}$″ and $^{1}/_{8}$″ Graduations

Name ______________________________ Overall Rating __________

Date ______________________________

Evaluation Criteria	**Rating**
• Accuracy with $^{1}/_{4}$″ graduations	______
• Accuracy with $^{1}/_{8}$″ graduations	______

Basic Skills

Reading Mathematics

Directions

In the following problems, measurements should be written as whole numbers, if possible. If not possible, write measurement as a whole number and a fraction. Write all fractions in their lowest terms. For example, $^{4}/_{8}$ or $^{8}/_{16}$ should be written as $^{1}/_{2}$.

1. Circle the preferred measurement in each of the pairs below.

   a. $5^{6}/_{8}$ or $5^{3}/_{4}$

   b. $^{1}/_{2}$ or $^{6}/_{12}$

   c. $1^{8}/_{16}$ or $1^{1}/_{2}$

   d. $7^{4}/_{16}$ or $7^{1}/_{4}$

   e. $3^{2}/_{8}$ or $3^{1}/_{4}$

2. Write the following measures in simplest form.

Example: $2^{10}/_{16} = 2^{5}/_{8}$

   a. $2^{8}/_{16}$

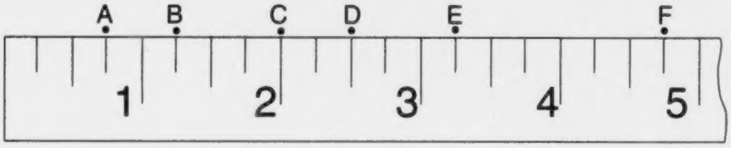
   b. $1^{6}/_{8}$

   c. $2^{8}/_{8}$

   d. $7^{14}/_{16}$

   e. $3^{3}/_{16}$

3. Give the preferred measurement for each of the points shown below.


A
B
C
D
E
F
1
2
3
4
5

a. Point A: ______________________

b. Point B: ______________________

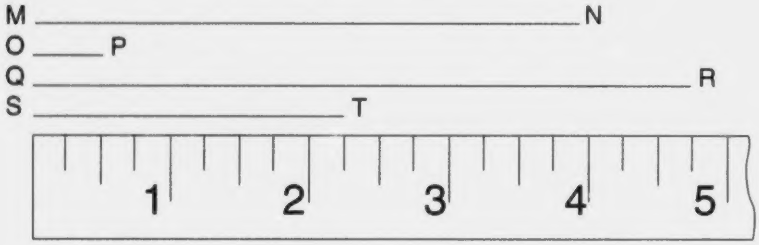
c. Point C: ______________________

d. Point D: ______________________

e. Point E: ______________________

f. Point F: ______________________

4. Give the measures of these line segments.


M
N
O
P
Q
R
S
T
1
2
3
4
5

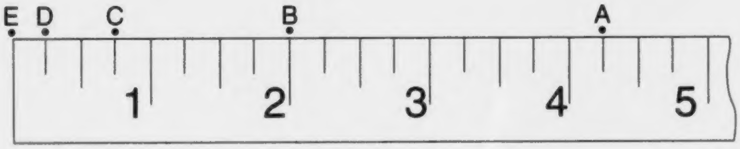
a. MN = ____________________

b. OP = ____________________

c. QR = ____________________

d. ST = ____________________

5. Which point on the rule below represents zero? ________________



6.

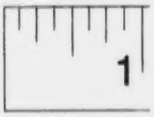


Figure A

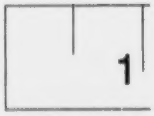


Figure B

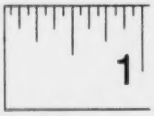


Figure C

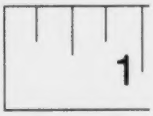


Figure D

a. In Figure A, the inch has been divided into ________________ parts.

b. In Figure B, the inch has been divided into ________________ parts.

c. In Figure C, the inch has been divided into ________________ parts.

d. In Figure D, the inch has been divided into ________________ parts.

e. When the inch is divided into two equal parts, each part is called a ____________.

f. When the inch is divided into four equal parts, each part is called a ____________.

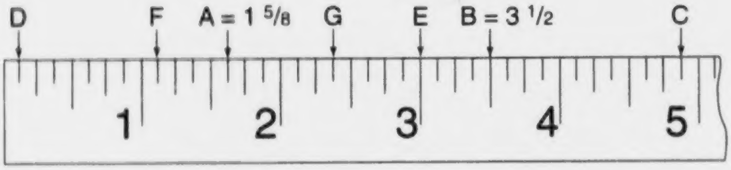
g. There are ____________ halves in 1 inch.

h. There are ____________ fourths in 1 inch.

7. a. Each inch on the rule shown below is divided into ____________ equal parts.

b. These equal parts are called ____________ of an inch.

c. How many eighths are in one inch? ________________



8. Give the reading of these points on the preceding rule.

   a. Point C: ____________________

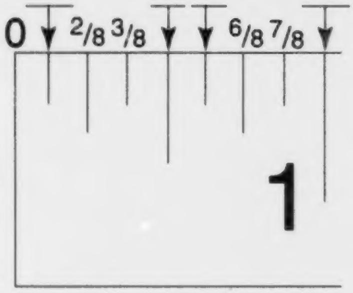
   b. Point D: ____________________

   c. Point E: ____________________

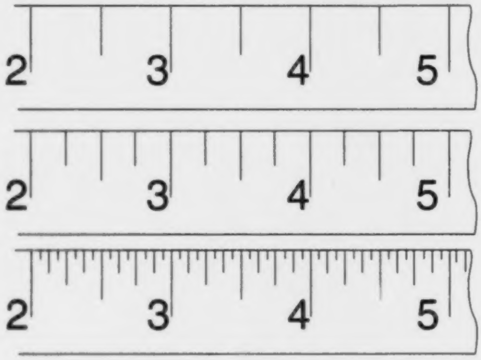
   d. Point F: ____________________

   e. Point G: ____________________

9. What fractions are missing? (Write all answers as eighths.)



10. In the figure below are three rules. One is divided into halves, one into fourths, and the other into eighths. Use these to complete the problems that follow.



a. $3\frac{1}{2} = 3\frac{\quad}{4} = 3\frac{\quad}{8}$

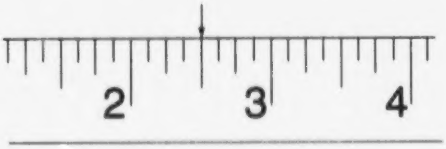
b. $2\frac{1}{4} = 2\frac{\quad}{8}$

c. $3\frac{3}{4} = 3\frac{\quad}{8}$

11. The arrow in the figure below points to a mark that can be read as 2^1/2. Give two other names for this point.

a. ____________________

b. ____________________



Objective 25

Assignment Sheet 11—Measure Distances with $^1/_8$″ Graduations

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	**Rating**
• Accuracy with point identification	______
• Accuracy with distance measurements	______

Basic Skills

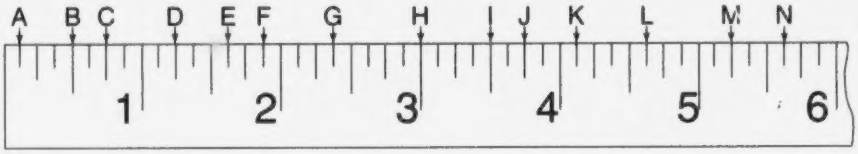
Reading

Mathematics

Directions

In problem 1, an indicated point means $2^1/_4$″ or whatever point is indicated. Problem 2 requires indicating distances from one point to another. Use the rule in the illustration.

1. Use the drawing below and give the reading of the indicated points. Be sure answers are in lowest terms.



a. ______________________

b. ______________________

c. ______________________

d. ______________________

e. ______________________

f. ______________________

g. ______________________

h. ______________________

i. ______________________

j. ______________________

k. ______________________

l. ______________________

m. ______________________

n. ______________________

2. Use the previous drawing to find the distance between the following letters. Give answers in lowest terms.

a. F to H ____________________

b. D to E ____________________

c. A to C ____________________

d. I to J ____________________

e. B to H ____________________

f. B to I ____________________

g. H to K ____________________

h. B to C ____________________

i. K to L ____________________

j. H to M ____________________

Objective 26

Assignment Sheet 12—Measure Distances with 1/16″ Graduations

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Accuracy with distance measurements	______
• Identification of missing fractions	______
• Evaluation of stated measurements	______

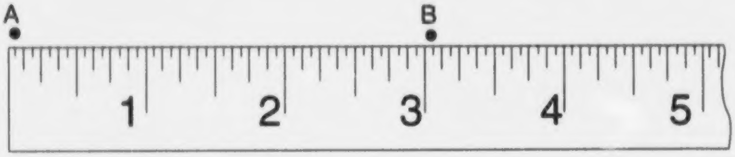
Basic Skills

Reading Mathematics

Directions

Study the rule in the illustration and carefully read the questions. Answer all questions in the form indicated.

1. a. Each inch on the rule below is divided into __________ equal parts.
   b. Each small unit represents what fraction of an inch? __________
   c. How many sixteenths in an inch? __________; a half inch? __________



   d. How far is Point A from the zero end of the rule? __________
   e. How far is Point B from the zero end of the rule? __________

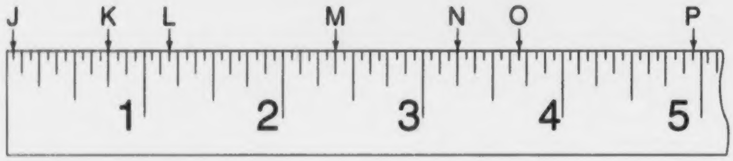
2. a. How many 1/2-inch units are in an inch? __________
   b. How many 1/8-inch units are in an inch? __________
   c. How many 1-inch units are in an inch? __________
   d. How many 1/4-inch units are in an inch? __________
   e. How many 1/16-inch units are in an inch? __________

3. a. Each inch on the rule shown below is divided into __________ equal parts.

b. Each part is called a __________________ of an inch.

c. There are how many sixteenths in one inch? ________________

d. There are how many sixteenths in one-half inch? ________________


J
K
L
M
N
O
P
1
2
3
4
5

4. Use the previous rule to answer these questions. Are these measures correct? Answer yes or no for each one.

a. J: 1/16 ________________________

b. K: 1/2 ________________________

c. L: 1 3/16 ________________________

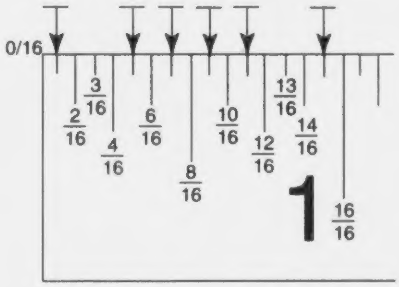
d. M: 2 3/8 ________________________

e. N: 3 1/8 ________________________

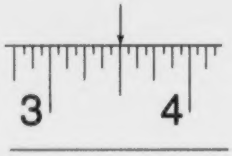
f. O: 3 11/16 ________________________

g. P: 4 7/8 ________________________

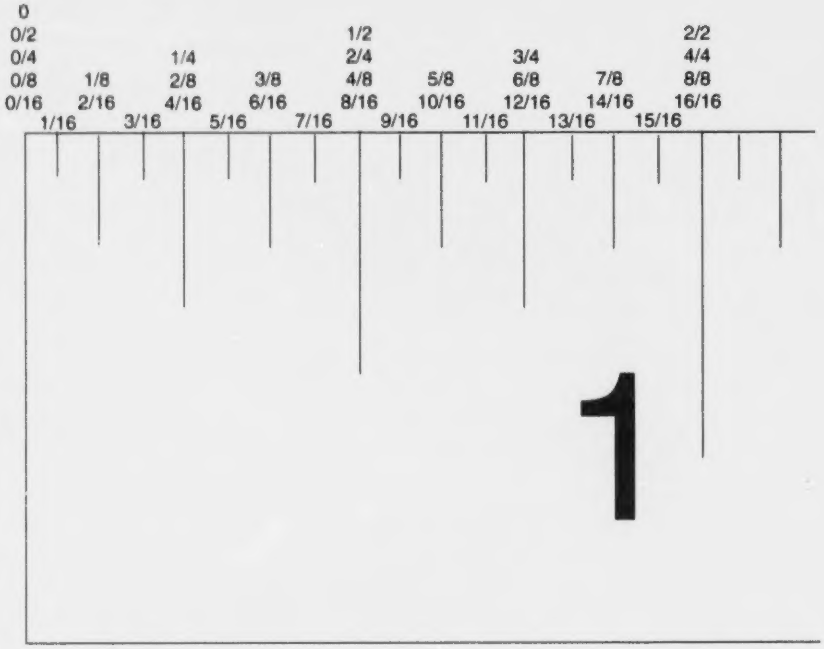
5. a. Name the missing fractions below:


0/16
3/16
2/16
4/16
6/16
8/16
10/16
12/16
13/16
14/16
1
16/16

b. The point marked on the rule below could be named $3\frac{8}{16}$. It could also be named $3\frac{\quad}{8}$, $3\frac{\quad}{4}$, or $3\frac{\quad}{2}$



6. The rule below shows that $\frac{1}{4}$, $\frac{2}{8}$, and $\frac{4}{16}$ are all names for the same point on the rule.


0
0/2
0/4
0/8
0/16
1/16
1/8
2/16
3/16
1/4
2/8
4/16
5/16
3/8
6/16
7/16
1/2
2/4
4/8
8/16
9/16
5/8
10/16
11/16
3/4
6/8
12/16
13/16
7/8
14/16
15/16
2/2
4/4
8/8
16/16
1

a. Another name for $\frac{2}{16}$ is ________________.

b. Other names for $\frac{12}{16}$ are ________________.

c. Other names for 1 inch are ________________.

d. Another name for $\frac{6}{16}$ is ________________.

e. The simplest name for $\frac{10}{16}$ is ____________.

f. $\frac{12}{16}$ reduced to lowest terms is ____________.

g. At the left end of the rule is the ______________ point.

h. Are the fractions $\frac{1}{16}$, $\frac{3}{16}$, $\frac{5}{16}$, $\frac{7}{16}$, $\frac{9}{16}$, $\frac{11}{16}$, $\frac{13}{16}$, and $\frac{15}{16}$, in simplest form? ________

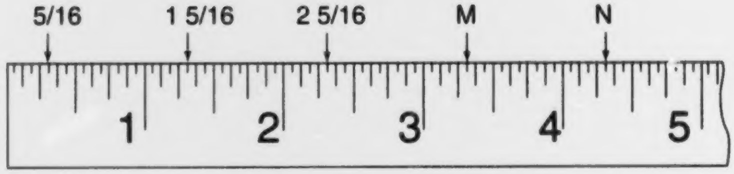
7. a. The following rule is divided into (16ths, 32nds). Circle the correct answer.

   b. The first five units on this rule represent 5/16 of an inch. Five small units to the right of the 1-inch mark is the mark representing 1 _____/16 inches.

   c. Five small units to the right of the 2-inch mark is the mark representing 2 ____/16 inches.

   d. Give the reading of point M. ________________

   e. Give the reading of point N. ________________



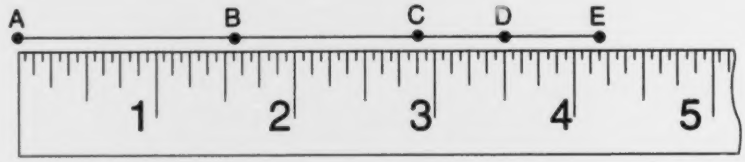
8. What are the measures of the following segments?

   a. AB = ______________

   b. AC = ______________

   c. AD = ______________

   d. AE = ______________



9. What is the length of JK in:

Note: Read the rule to the nearest mark.

a. Figure A ____________________

b. Figure B ____________________

c. Figure C ____________________

d. Figure D ____________________

e. Figure E ____________________

f. Which figure shows the rule that would give the most accurate measure of JK? ____________________

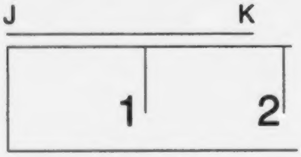


Figure A

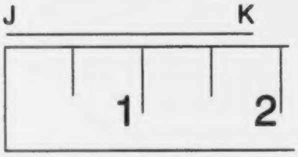


Figure B

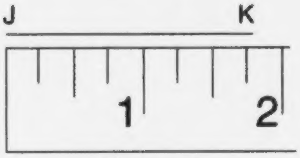


Figure C

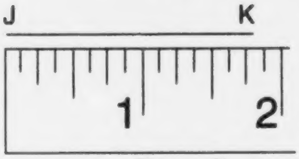


Figure D

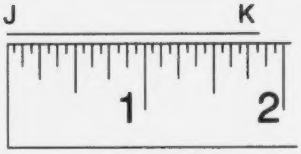


Figure E

Objective 27

Assignment Sheet 13—Make Conversions with an English-Metric Conversion Chart

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Accuracy of length conversions	______
• Accuracy of weight conversions	______

Basic Skills

Reading Mathematics

Directions

Use the English-Metric conversion chart that accompanies this assignment sheet to identify English measurement and the metric measurement you want to convert it to. Multiply by the conversion factor to arrive at your answer to the following problems; it may pay to use decimal equivalents in certain cases.

1. The wall thickness of a piece of steel tubing is 1/64′. How many centimeters thick is the steel tubing? ______________
2. A piece of steel round bar is 16′ long. How many meters long is the bar? ______________
3. A bag of flux weights 3 kilograms. How many pounds does the flux weigh? ______________
4. A sheet of mild steel weighs 18 kilograms. How many pounds does the steel sheet weigh? ______________

ENGLISH-METRIC CONVERSION CHART

	When You Know	You Can Convert To	When You Multiply By the Conversion Factor
LENGTH	Inches	Millimeters (mm)	25.4
	Millimeters	Inches	0.04
	Inches	Centimeters (cm)	2.54
	Centimeters	Inches	0.4
	Inches	Meters (m)	0.0254
	Meters	Inches	39.37
	Feet	Centimeters	30.5
	Centimeters	Feet	4.8
	Feet	Meters	0.305
	Meters	Feet	3.28
	Miles	Kilometers (km)	1.61
	Kilometer	Miles	0.62
WEIGHT MASS	Ounces	Grams	28.4
	Grams	Onces	0.035
	Pounds	Kilograms	0.45
	Kilograms	Pounds	2.2

Objective 28

Assignment Sheet 14—Calculate Area of Geometric Figures

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Completed all problems and showed work	______
• Labeled answers with correct unit of measurement	______
• Computed a minimum of 21 of the 24 answers correctly per Assignment Sheet 14 answers	______

Basic Skills

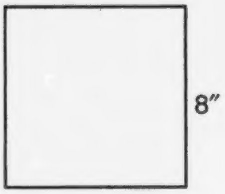
Reading Mathematics

Directions

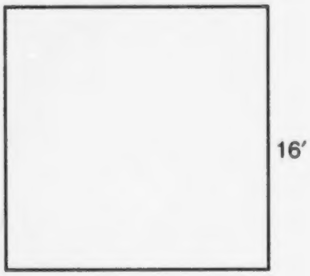
Calculate area for the following problems.

a. Calculate the area for each of the following squares.

1.



2.



A = __________

A = __________

3. Square = 15 feet

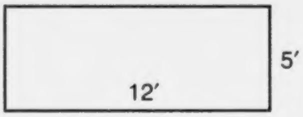
4. Square = 36 yards

A = __________

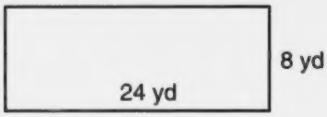
A = __________

b. Calculate area for each of the following rectangles.

1.



2.



A = __________

A = __________

3. L = 17″; W = 31″

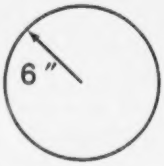
4. L = 16′; W = 62′

A = __________

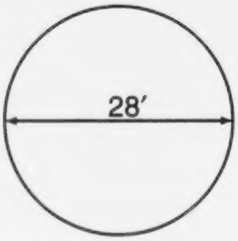
A = __________

c. Calculate area for each of the following circles. (Use $\pi = 3.14$.)

1.



2.



A = __________

A = __________

3. Radius = 16′

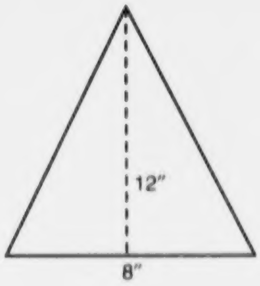
4. Diameter = 25 yards

A = __________

A = __________

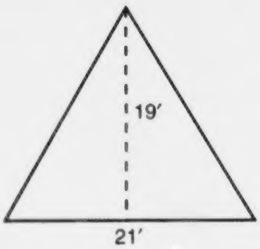
d. Calculate area for each of the following triangles.

1.



A = ____________

2.



A = ____________

3. b = 13″; h = 3″

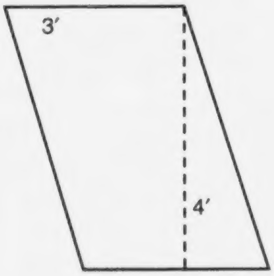
A = ____________

4. b = 24 yards; h = 15 yards

A = ____________

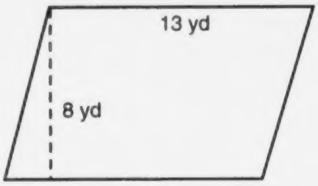
e. Calculate area for each of the following parallelograms.

1.



A = ____________

2.



A = ____________

3. b = 16″; h = 16″

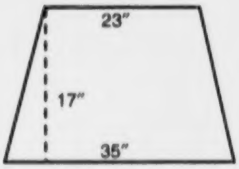
A = ____________

4. b = 27 yards; h = 9 yards

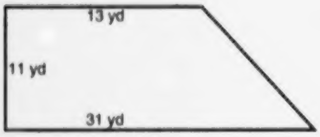
A = ____________

f. Calculate area for each of the following trapezoids.

1.



2.


13 yd
11 yd
31 yd

A = ____________

A = ____________

3. $h = 12'$; $b_1 = 9'$; $b_2 = 19'$

4. $h = 17$ yards; $b_1 = 39$ yards; $b_2 = 51$ yards

A = ____________

A = ____________

Objective 29

Job Sheet 1—Adjust a Bevel Square to a 45° Angle Using a Framing Square, a Combination Square, and a Protractor

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Angle adjustment with framing square	______
• Angle adjustment with combination square	______
• Angle adjustment with protractor	______

Basic Skills

Reading Mathematics Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, equipment, and materials

- Bevel square
- Framing square
- Combination square
- Protractor
- Safety glasses

Procedure

Note: The illustrations and procedures in this job sheet are adapted from materials originally published by the Research and Curriculum Unit for Vocational-Technical Education, College of Education, Mississippi State University, Mississippi State, MS, and are reprinted with permission.

☐ 1. Put on safety glasses.

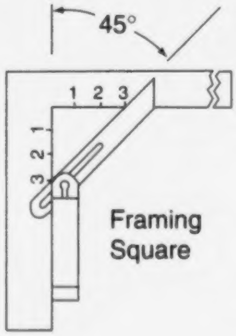
☐ 2. Place the framing square on a clean work area.

☐ 3. Loosen the locking screw on the bevel square so that the blade moves with a slight friction.

☐ 4. Place the handle along the inside of the blade of the framing square so that it is straight against the framing square.

☐ 5. Adjust the blade on the bevel square so that it is at a graduation on the tongue of the framing square equal to the graduation scale at the handle of the bevel square.

Figure 1



☐ 6. Hold the bevel square with one hand and tighten the locking screw with the other hand.

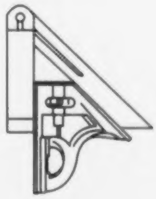
☐ 7. Have your instructor check for an exact 45° angle on your bevel square.

☐ 8. Loosen the thumb screw on a combination square and slide the handle off the scale.

☐ 9. Loosen the locking screw on the bevel square so that the blade moves with a slight friction.

☐ 10. Place the handle of the combination square on a clean work area, hold it in place with one hand, adjust the blade on the bevel square so that it fits firmly over the 45° angle on the combination square, then tighten the bevel square locking screw.

Figure 2



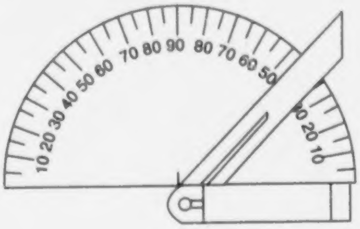
☐ 11. Have your instructor check for an exact 45° angle on your bevel square.

☐ 12. Place a protractor on a clean work area.

☐ 13. Loosen the locking screw on the bevel square so that the blade moves with a slight friction.

☐ 14. Place the handle of the bevel square at the bottom edge of the protractor, hold it with one hand so that it is straight, exactly over the 45° angle on the protractor, then tighten the locking screw.

Figure 3



☐ 15. Have your instructor check for an exact 45° angle on your bevel square.

☐ 16. Return tools and materials to proper storage area.

Evaluator's Comments: ____

____

____

Objective 30

Job Sheet 2—Form 90° and 45° Angles with a Combination Square and Draw Parallel Lines on Metal Stock

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• 90° angle formation	______
• 45° angle formation	______
• Creation of parallel lines	______

Basic Skills

Reading Mathematics Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, equipment, and materials

- Combination square
- Framing square
- Sharpened soapstone
- Flat metal stock as selected by instructor
- Safety glasses

Procedure

Note: The illustrations and procedures in this job sheet are adapted from materials originally published by the Research and Curriculum Unit for Vocational-Technical Education, College of Education, Mississippi State University, Mississippi State, MS, and are reprinted with permission.

☐ 1. Put on safety glasses.

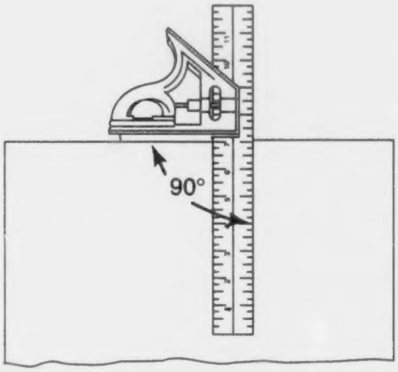
☐ 2. Place flat metal stock on a clean working area.

☐ 3. Butt the flat part of the handle along the upper edge of the metal stock so the scale forms a 90° angle down the surface of the metal.

☐ 4. Loosen the thumb screw on the bevel and move the scale down the metal to a point where it indicates exactly 6″, then tighten the thumb screw.

☐ 5. Mark the 6″, 90° angle with soapstone.

Figure 1



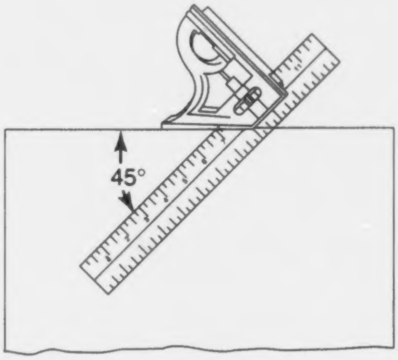
☐ 6. Have your instructor check for an exact 90° angle and a distance of exactly 6″.

☐ 7. Butt the flat part of the handle along the upper edge of the metal stock so the scale forms a 45° angle down and across the surface of the metal.

☐ 8. Loosen the thumb screw on the combination square and move the scale down the metal to a point where it indicates exactly 6″, then tighten the thumb screw.

☐ 9. Mark the 6″, 45° angle with soapstone.

Figure 2



☐ 10. Have your instructor check for an exact 45° angle and a distance of exactly 6″.

☐ 11. Loosen the thumb screw and slide the scale out the 90° side of the handle to prepare for marking parallel lines on the metal.

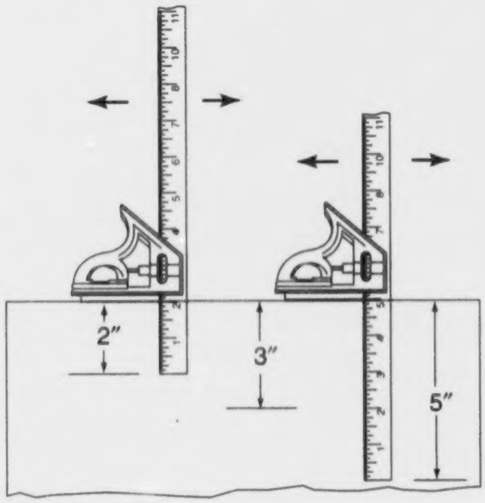
☐ 12. Place the scale on the 2″ mark and tighten the thumb screw.

☐ 13. Mark the 2″ distance in two places along the left and right side of the metal.

☐ 14. Reset the scale at the 3″ mark and mark the 3″ distance at two places along the left and right side of the metal.

☐ 15. Reset the scale at the 5″ mark and mark the 5″ distance at two places along the left and right side of the metal.

Figure 3



☐ 16. Remove the combination square.

☐ 17. Line up the framing square along both 2″ marks and draw a straight line across the metal with soapstone.

☐ 18. Line up the framing square along both 3″ marks and draw a straight line across the metal with soapstone.

☐ 19. Line up the framing square along both 5″ marks and draw a straight line across the metal with soapstone.

☐ 20. Have your instructor check your work for parallel lines across the metal at points exactly 2″, 3″, and 5″ from the top.

☐ 21. Return tools and materials to proper storage areas.

Evaluator's Comments: ______________________________

Objective 17

Assignment Sheet 1—Construct a Top View

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Proper construction of top views	______
• Number of constructions completed	______

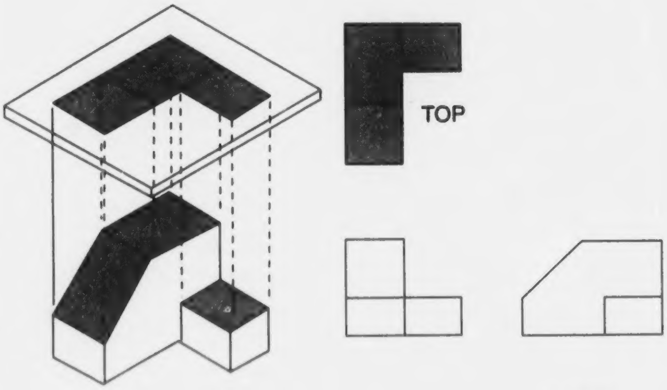
Basic Skills

Reading Writing Critical Thinking Science

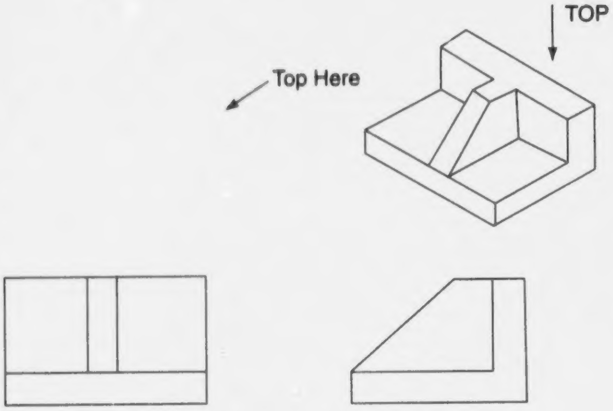
Directions

Study the example carefully and use it as a guide for constructing the top views that follow. Be sure to align views properly so you can transfer lines.

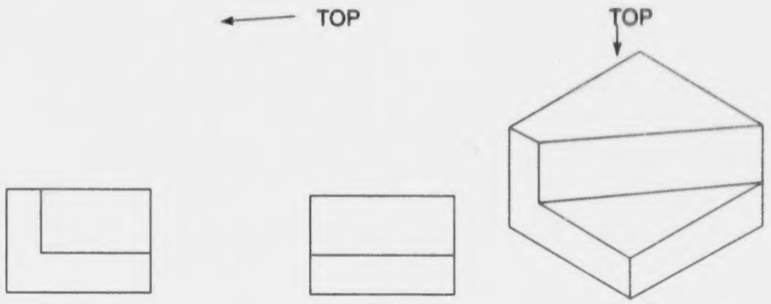
Example



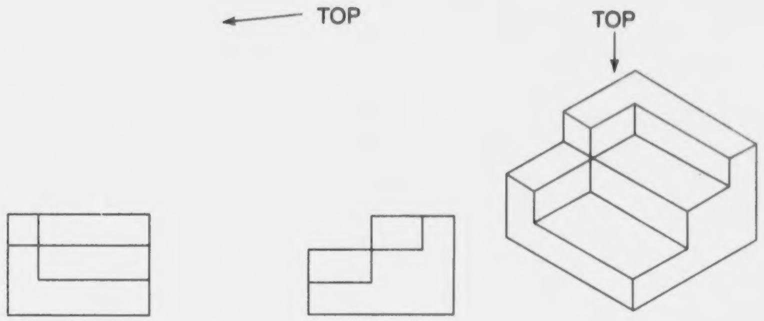
Problem 1



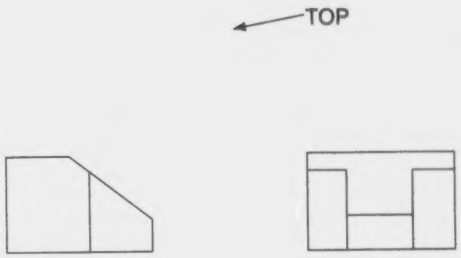
Problem 2



Problem 3



Problem 4



Objective 18

Assignment Sheet 2—Construct a Front View

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	**Rating**
• Proper construction of front views	______
• Number of constructions completed	______

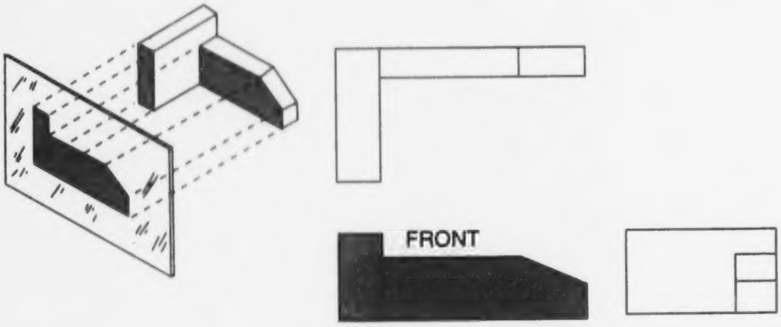
Basic Skills

Reading Writing Critical Thinking Science

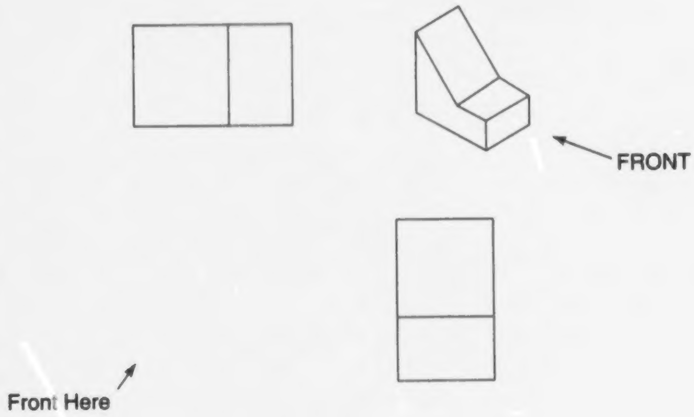
Directions

Study the example carefully and use it as a guide for constructing the front views that follow. Be sure to align views properly so you can transfer lines.

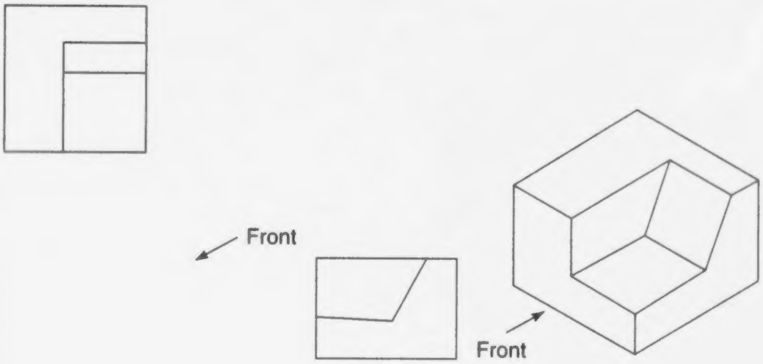
Example



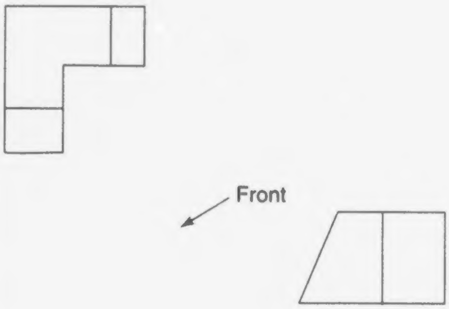
Problem 1



Problem 2


Front
Front

Problem 3



Objective 19

Assignment Sheet 3—Construct a Right Side View

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Proper construction of side views	______
• Number of constructions completed	______

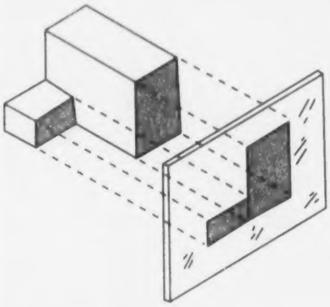
Basic Skills

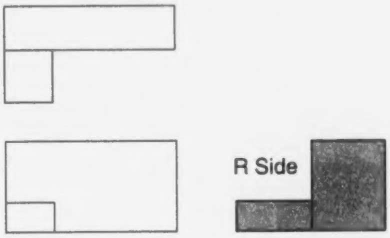
Reading Writing Critical Thinking Science

Directions

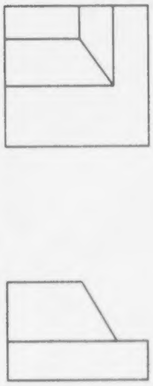
Study the example carefully and use it as a guide for constructing the right side views that follow. Be sure to align views properly so you can transfer lines.

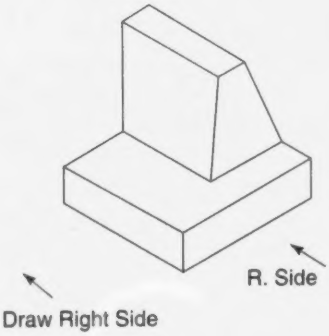
Example



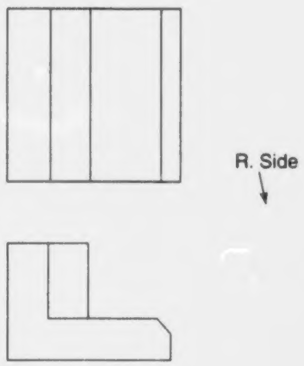


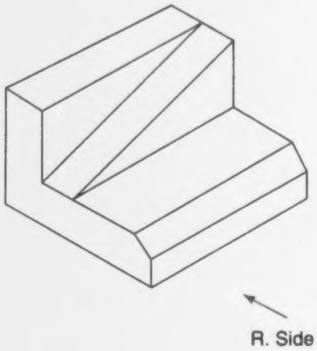
Problem 1



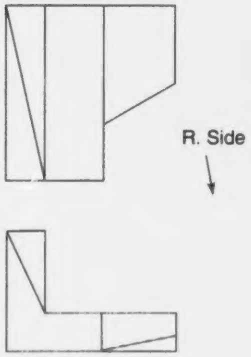


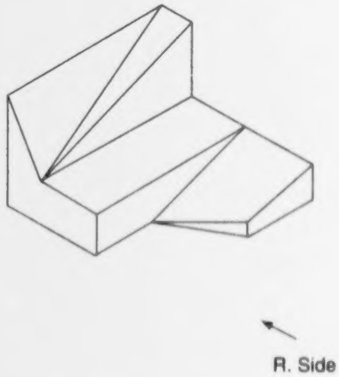
Problem 2



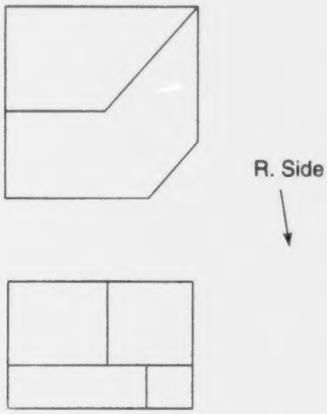


Problem 3





Problem 4



Objective 20

Assignment Sheet 4—Construct Missing Hidden Lines

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	**Rating**
• Proper construction of hidden lines	______
• Number of constructions completed	______

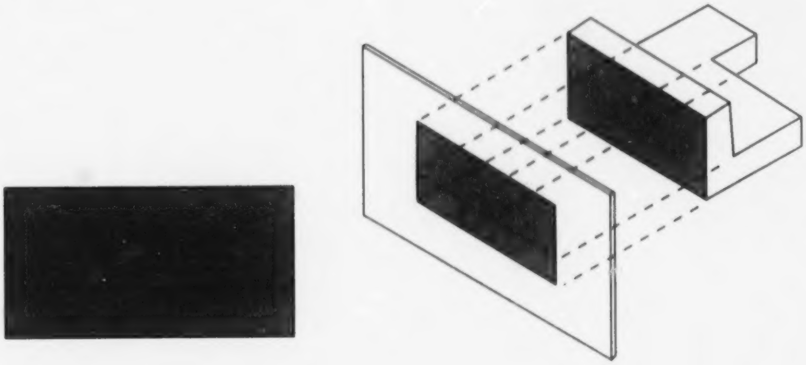
Basic Skills

Reading Writing Critical Thinking Science

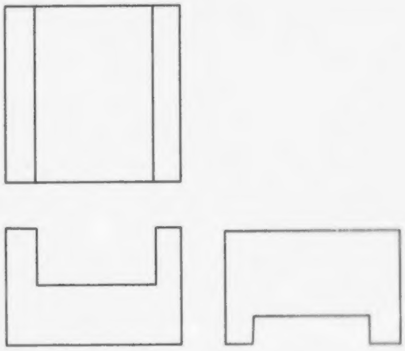
Directions

Study the example carefully and use it as a guide for constructing the missing hidden lines that follow. Be sure to align views properly so you can transfer lines.

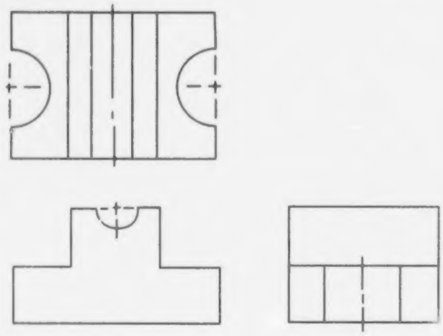
Example



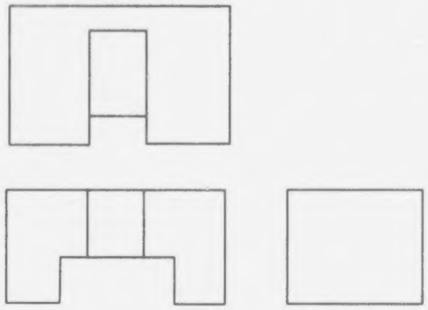
Problem 1



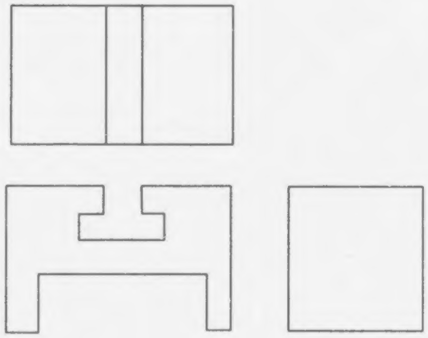
Problem 2



Problem 3



Problem 4



Objective 21

Assignment Sheet 5—Interpret Tolerance Dimensions in Decimals, Fractions, and Degrees

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Expression of decimal tolerances	______
• Expression of fractional tolerances	______
• Expression of degree tolerances	______

Basic Skills

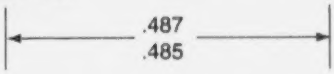
Reading Critical Thinking Mathematics

Directions

Study the example of expressing tolerances in decimals, fractions, and degrees. Use the examples as guidelines to complete the tolerance problems that follow.

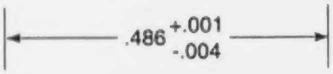
Examples

1.



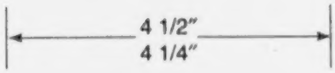
.487 Maximum limit
.485 Minimum limit
.002 Total tolerance

2.



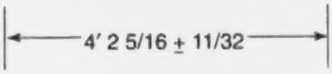
.487 Maximum limit
.482 Minimum limit
.005 Total tolerance

3.



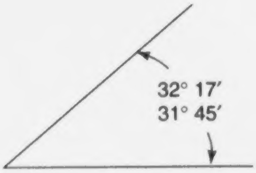
4$^{1}/_{2}$ Maximum limit
4$^{1}/_{4}$ Minimum limit
$^{1}/_{4}$ Total tolerance

4.



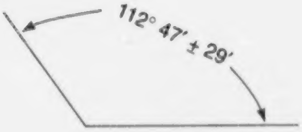
4′ 2$^{21}/_{32}$″ Maximum limit
4′ 1$^{31}/_{32}$″ Minimum limit
$^{22}/_{32}$″ Total tolerance

5.



32° 17′ Maximum limit
31° 45′ Minimum limit
32′ Total tolerance

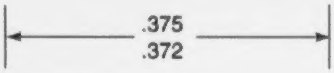
6.



113° 16′ Maximum limit
112° 18′ Minimum limit
58′ Total tolerance

Directions Determine decimal tolerance dimensions for the following problems.

Problem 1

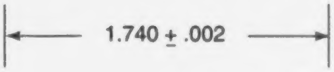


Maximum limit =

Minimum limit =

Total tolerance =

Problem 2

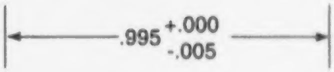


Maximum limit =

Minimum limit =

Total tolerance =

Problem 3



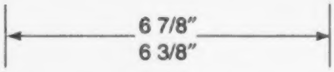
Maximum limit =

Minimum limit =

Total tolerance =

Directions Determine fractional tolerance dimensions for the following problems.

Problem 4

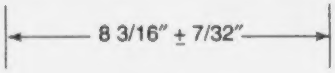


Maximum limit =

Minimum limit =

Total tolerance =

Problem 5

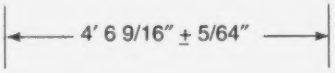


Maximum limit = ______________________________

Minimum limit = ______________________________

Total tolerance = ______________________________

Problem 6



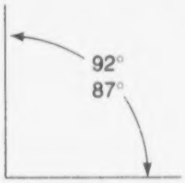
Maximum limit = ______________________________

Minimum limit = ______________________________

Total tolerance = ______________________________

Directions Determine degree tolerance dimensions for the following problems.

Problem 7

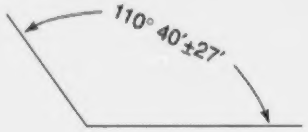


Maximum limit = ______________________________

Minimum limit = ______________________________

Total tolerance = ______________________________

Problem 8

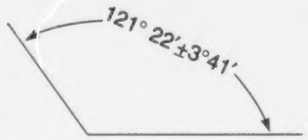


Maximum limit = ______________________________

Minimum limit = ______________________________

Total tolerance = ______________________________

Problem 9



Maximum limit = ______________________________

Minimum limit = ______________________________

Total tolerance = ______________________________

Objective 22

Assignment Sheet 6—Construct Missing Visible and Hidden Lines

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	**Rating**
• Proper construction of visible and hidden lines	______
• Number of constructions completed	______

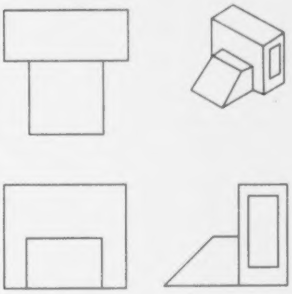
Basic Skills

Reading Writing Critical Thinking Science

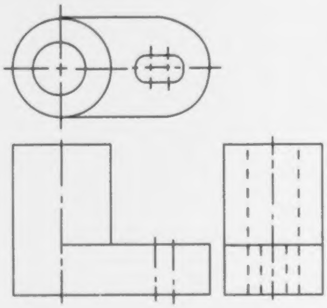
Directions

Study the example carefully and use it as a guide for constructing the missing visible and hidden lines that follow. Be sure to align views properly so you can transfer lines.

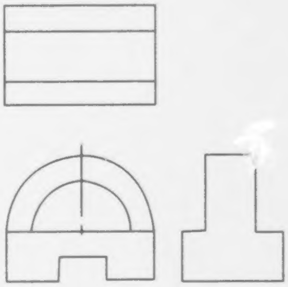
Problem 1:



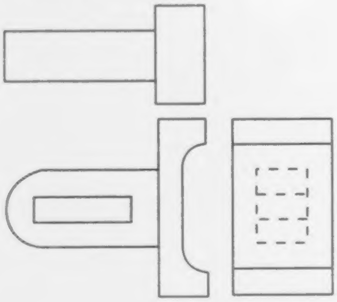
Problem 2:



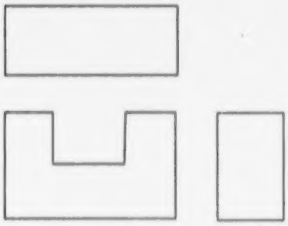
Problem 3:



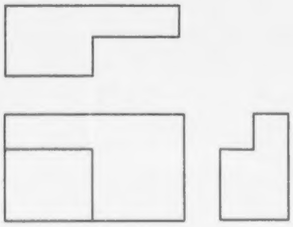
Problem 4:



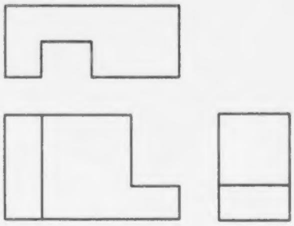
Problem 5:



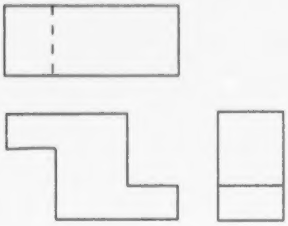
Problem 6:



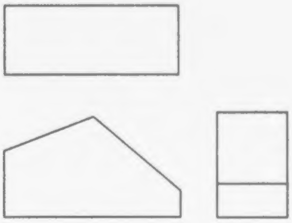
Problem 7:



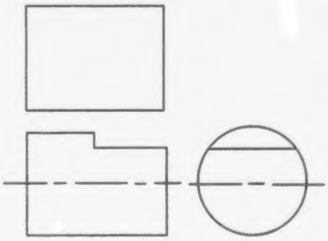
Problem 8:



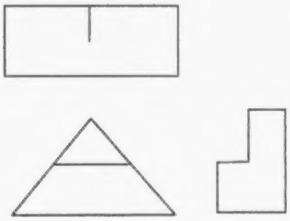
Problem 9:



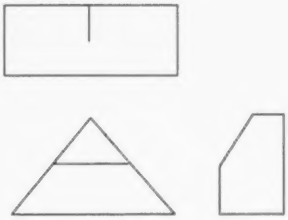
Problem 10:



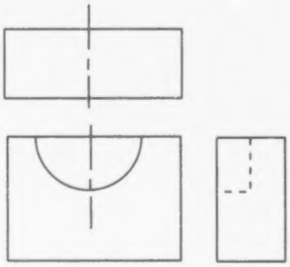
Problem 11:



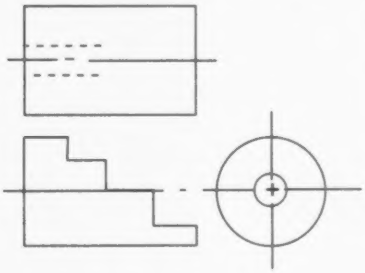
Problem 12:



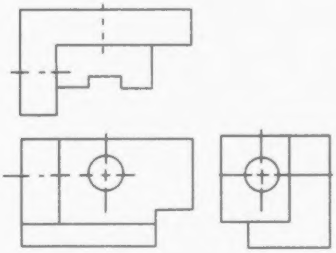
Problem 13:



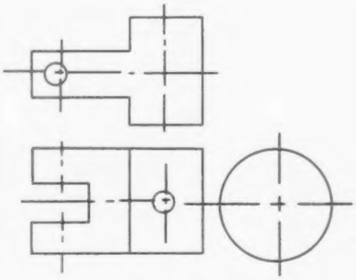
Problem 14:



Problem 15:



Problem 16:



Objective 23

Assignment Sheet 7—Make a Three-View Sketch

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	**Rating**
• Proper construction lines	______
• Presentation of details	______
• Final presentation	______

Basic Skills

Reading Writing Critical Thinking Science

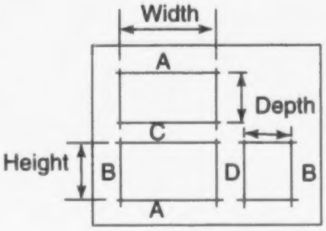
Directions

Study the example given and then complete the following problem.

Example

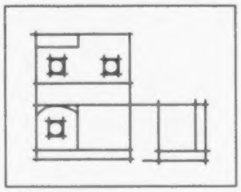
1. Sketch the horizontal lines to locate the height of the object.

   Note: The distance at the top and bottom of the paper should be the same. The distance between the top and front views can be the same as that on the top and bottom or slightly less than that space.

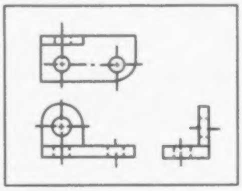


2. Sketch the vertical lines to locate the width and depth of the object.

   Note: The distance at the left side and right side of the paper should be the same. The distance between the views can be the same as that on the left side and right side or slightly less than that space. In the top and side views, the depth must be equal; this can be done by marking a piece of paper with depth.



3. Block in details using diagonals to locate centers, if necessary, and lightly sketch the circles and arcs.



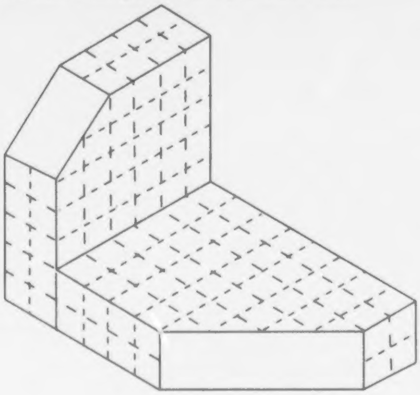
4. Add line features to the views of the object.

5. Use an artgum eraser to dim construction lines and darken in visible lines

Assignment Sheet 7

Problem

Sketch three views of the object below using the grid provided for measurements or gridded drawing media if requested by instructor.



Objective 24

Assignment Sheet 8—Construct Adjacent Parts in an Assembly Section

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Lines drawn at proper degrees	______
• Proper material presentation	______

Basic Skills

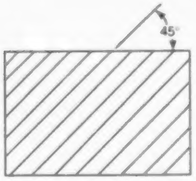
Reading Writing Critical Thinking Science

Directions

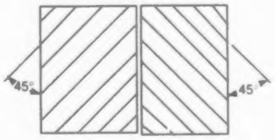
Study the example carefully and use it as a guideline to complete the assemblies in the following problems.

Example

1. The first section lines are constructed at an angle of 45° to the main outline of the object.

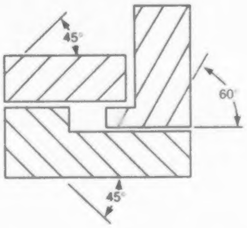


2. On adjacent parts, section lines should be 45° in the opposite direction.

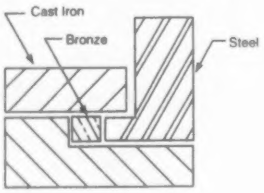


3. For more than two parts adjacent to each other, section lines should be drawn at an angle of 30° or 60°.

   Note: Section lines should not be drawn to meet common lines.



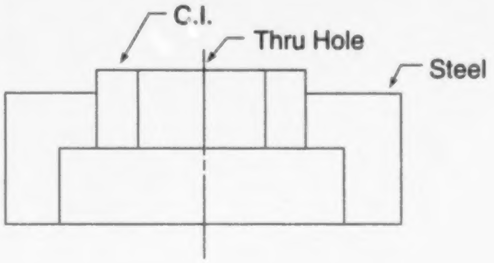
4. Different materials can be used to represent different parts in section.



Directions

Complete this assembly as a section using the proper symbols. Refer to the items in the Information Sheet if you need to.

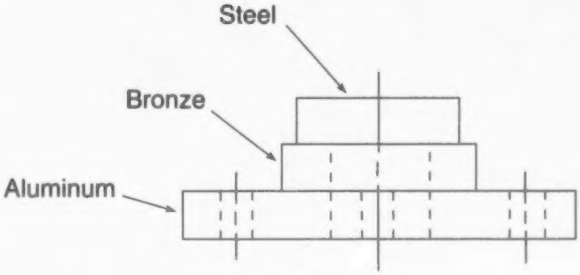
Problem A


C.I.
Thru Hole
Steel

Directions

Complete front view using the symbols called for. Refer to the items in the Information Sheet if you need to.

Problem B


Steel
Bronze
Aluminum

Objective 15

Assignment Sheet 1—Identify Basic Weld Symbols

Name ______________________ Overall Rating __________

Date ______________________

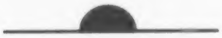
Evaluation Criteria	**Rating**
• Identification of basic weld symbol	_____
• Arrow side, other side interpretations	_____
• Significant other information	_____

Basic Skills

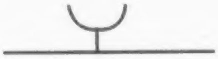
Reading Critical Thinking

Directions

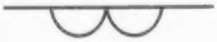
Study each symbol carefully, then identify the symbol.



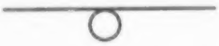
1. ______________________



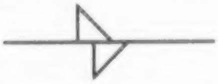
2. ______________________



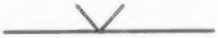
3. ______________________



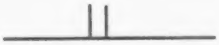
4. ______________________



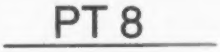
5. ______________________



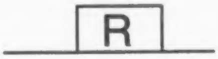
6. ______________________



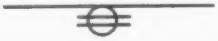
7. ______________________



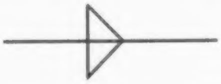
8. ______________________



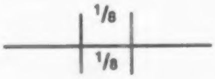
9. ______________________



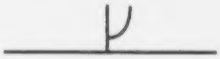
10. ______________________



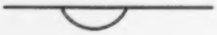
11. ______________________



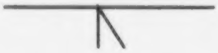
12. ______________________



13. ______________________________



14. ______________________________



15. ______________________________

Objective 16

Assignment Sheet 2—Interpret Basic Welding Symbols

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Identification of basic weld symbol	______
• Identification of dimensions and sizes	______
• Arrow side, other side interpretations	______
• Procedure or finishing information	______
• Significant other information	______

Basic Skills

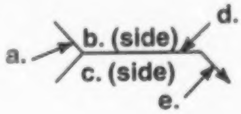
Reading

Critical Thinking

Directions

Study each of the following welding symbols carefully and interpret all of the items that follow. Be sure to indicate arrow side or other side when identifying the basic weld symbol. Other significant information may include specifications such as backing or weld all around. Be sure to complete all items.

1.



a. ______________

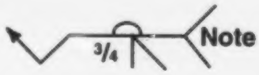
b. ______________

c. ______________

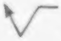
d. ______________

e. ______________

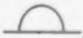
2.

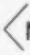


a. 3/4 ____________

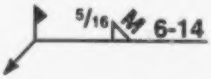
b.  ____________

c. ____________

d.  ____________

e.  Note ____________

3.



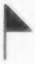
a. 5/16 ____________

b. 6 ____________

c. 14 ____________

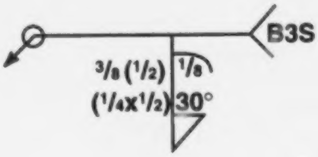
d. ____________

e. M ____________

f.  ____________

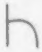
g. ____________

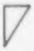
4.


3/8 (1/2)
1/8
(1/4x1/2)
30°
B3S

a. 3/8 ______________

b. (1/2) ______________

c.  ______________

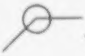
d.  ______________

e. 1/8 ______________

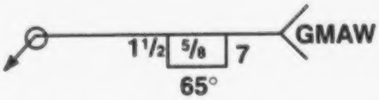
f. 30° ______________

g. (1/4x1/2) ______________

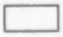
h. B3S ______________

i.  ______________

5.


1 1/2
5/8
7
65°
GMAW

a. 1 1/2 ______________

b.  ______________

c. 5/8 ______________

d. 7 ______________

e. 65° ______________

f. GMAW ______________

Objective 17

Assignment Sheet 3—Interpret Working Welding Symbols

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Identification of basic weld symbol	______
• Arrow side, other side interpretations	______
• Items of special significance	______

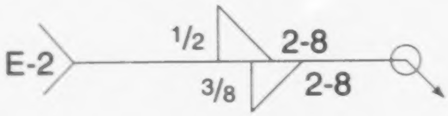
Basic Skills

Reading Writing Critical Thinking

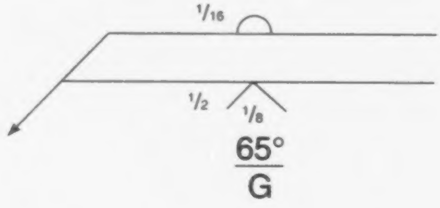
Directions

Study each of the following welding symbols carefully. Your interpretation should include the weld symbol, sizes, dimensions, and all other items that have significance to a particular symbol. Make your entries in the spaces provided. Make your work easier by reading the symbols in order such as right to left, left to right, arrow to other side, or whatever order seems most appropriate to the interpretation.

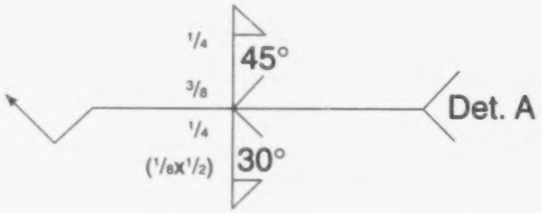
1.



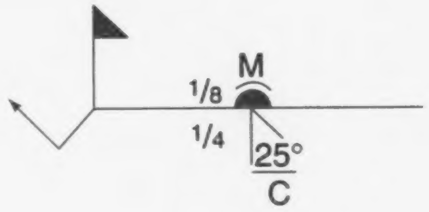
2.


1/16
1/2
1/8
65°
G

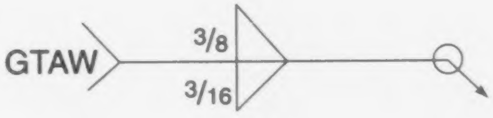
3.


1/4
45°
3/8
1/4
(1/8x1/2)
30°
Det. A

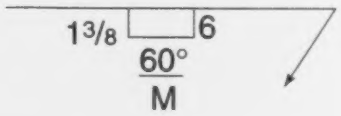
4.



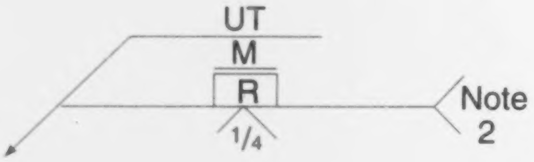
5.



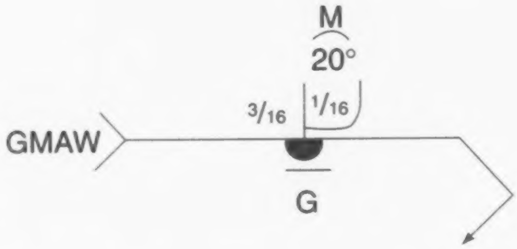
6.



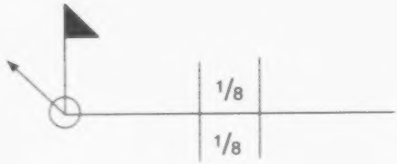
7.


UT
M
R
1/4
Note 2

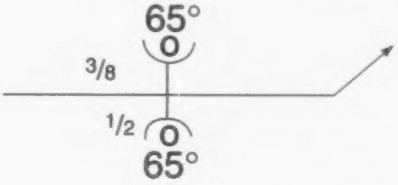
8.


M
20°
3/16
1/16
GMAW
G

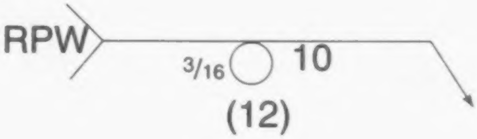
9.



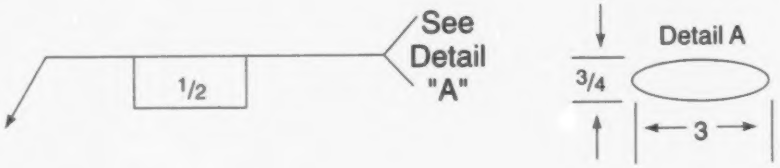
10.



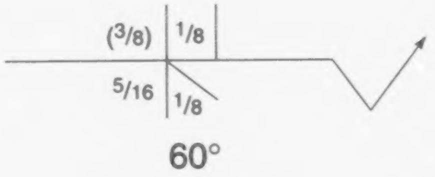
11.


RPW
3/16
10
(12)

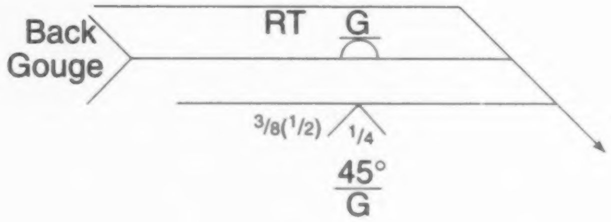
12.


1/2
See Detail "A"
Detail A
3/4
3

13.


(3/8)
1/8
5/16
1/8
60°

14.


Back
Gouge
RT
G
3/8(1/2)
1/4
45°
G

Objective 18

Assignment Sheet 4—Draw Welding Symbols for Given Specifications

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Presentation of basic weld symbol	______
• Arrow side, other side interpretations	______
• Presentation of other significant information	______

Basic Skills

Reading Writing Critical Thinking

Directions

Read the following specifications carefully. Determine arrow side, other side information before you draw the welding symbol. Be sure to put other significant information in the correct positions. Sketch rough symbol on the other paper, then place it below the specifications in finished form.

1. Specification: 1/2″ fillet on arrow side, machined convex. 3/8″ fillet on other side, grind flush.

2. Specification: 1/4″ V-groove with 3/8″ weld size on arrow side. 1/8″ bevel groove with 1/4″ weld size on other side.

3. Specification: A resistance seam weld with a 3000 lb. shear strength. There is no arrow or other side significance.

4. Specification: Other side 3/8″ plug weld, filled 1/2″ deep with a 30° angle. There should be 10 welds spaced with a 5″ pitch.

5. Specification: An arrow side V-groove weld with a 1/16″ root opening, 30° included angle, and a 1/32″ back weld on the other side.

6. Specification: An other side bevel groove weld with a 1/4″ groove depth and 1/2″ weld size.

7. Specification: An arrow side surfacing weld with a 3/8″ build-up, machined flush.

8. Specification: Six spot welds on the arrow side with 1/2″ diameter, with a 6″ pitch. Finish flush by grinding and use gas tungsten arc welding.

9. Specification: Six stud welds on the arrow side with a 3″ pitch. 1/4″ stud size made with gas metal arc welding.

10. Specification: Square groove with 1/8″ root opening, weld arrow side with melt through. Grind flush on both sides.

Objective 19

Assignment Sheet 5—Interpret a Welding Print and Welding Procedure Specifications

Name ______________________________ Overall Rating __________

Date ______________________________

Evaluation Criteria	Rating
• Welding print interpretation	______
• Welding procedures interpretation	______

Basic Skills

Reading Writing Critical Thinking

Directions

Welding Print 1 which accompanies this assignment sheet is a typical manufacturing print used in an industrial application. By studying the bill of material, you should be able to determine the kind of material, sizes, and the number of pieces required for completing the welding project. Note that all material is numbered to correspond with the place a particular piece must be located so that the correct assembly of the weldment can be completed. The five welding procedure specifications that also accompany this assignment sheet will help you interpret the type of weld, the location, weld size, and the welding process specified. Study the bill of material and read through the welding procedure specifications, and then answer the questions that follow. Circle the item that best answers each question.

1. How many pieces make up the welded assembly?

   a. 8
   b. 6
   c. 7
   d. 5

2. In how many welds is the gas tungsten arc welding process used?

   a. 3
   b. 4
   c. 6
   d. 5

3. What is the included angle on all groove welds?

   a. 30°
   b. 40°
   c. 60°
   d. 90°

4. What process is used for welding procedure number five?

   a. SMAW
   b. GTAW
   c. GMAW
   d. SMAW, GTAW, and GMAW

5. What is the welding current used for welding procedure two?

   a. Alternating
   b. Direct current
   c. Either AC or DC
   d. Direct current, electrode positive

6. On what welds are root openings required?

   a. Bevel groove welds
   b. V-groove welds
   c. Fillet welds
   d. J-groove welds

7. Where should the 1/4" leg fillet welds be made?

   a. Arrow side
   b. Other side
   c. Either side
   d. None of the locations in a, b, or c

8. The metal transfer used with the gas metal arc welding process is what kind?

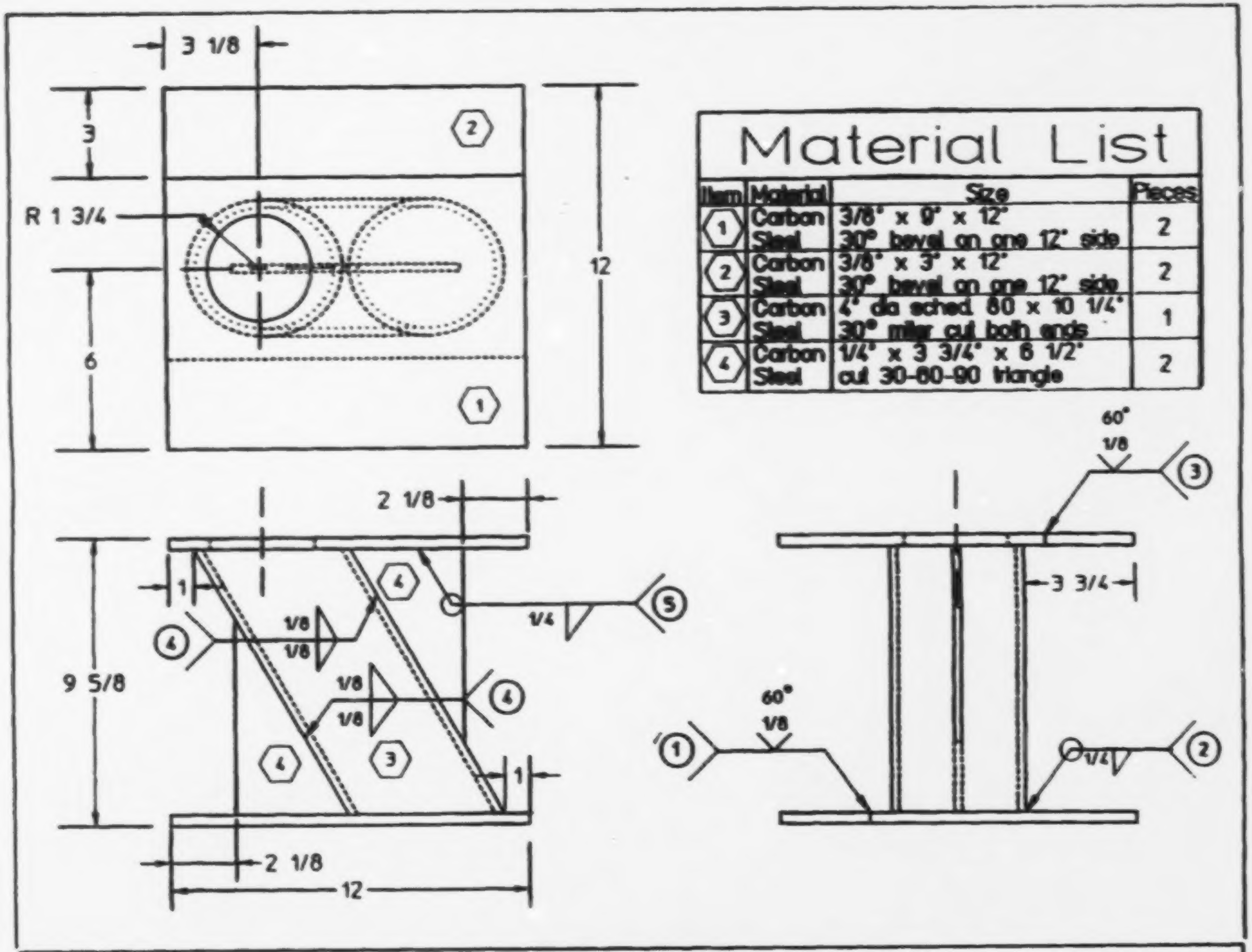
   a. Short circuit
   b. Globular
   c. Spray
   d. Alternating

9. The weld all around symbol is used in what welding procedures?

   a. 1 and 3
   b. 2 and 4
   c. 3 and 5
   d. 2 and 5

10. What AWS class electrodes are used in the shielded metal arc welding process?

    a. E6010 and E7018
    b. E7018 only
    c. E6010 only
    d. E7024 and E7018


3 1/8
3
R 1 3/4
6
12
2 1/8
1
9 5/8
1/8
1/8
1/8
1/8
1/4
1
2 1/8
12
60°
1/8
3 3/4
60°
1/8
1/4
①
②
③
④
⑤

Material List			
Item	Material	Size	Pieces
①	Carbon Steel	3/8" x 9" x 12" 30° bevel on one 12" side	2
②	Carbon Steel	3/8" x 3" x 12" 30° bevel on one 12" side	2
③	Carbon Steel	4" dia sched. 80 x 10 1/4" 30° miter cut both ends	1
④	Carbon Steel	1/4" x 3 3/4" x 6 1/2" cut 30-60-90 triangle	2

Welding Print #1

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Procedure No. WP-1

WELDING PROCEDURE SPECIFICATION

Material Specification 3/8" Carbon Steel Plate (ASTM A-36) to 3/8" Carbon Steel Plate (ASTM A-36)

Welding Process GMAW Transfer Mode Spray

Manual — Semi-Automatic X Automatic — Machine —

Weld Position: 1 F/G x 2 F/G — 3 F/G — 4 F/G — 5 G — 6G —

AWS Filler Metal Spec: A5.18 - 79 AWS Filler Metal Class: ER - 70S - 6

AWS Flux Spec N/A Weld Metal Grade N/A

Shielding Gas Composition Argon (89%)/Oxygen (2%) Flow Rate (CFH) 30-40

Passes: Single — Multiple X Arc: Single X Multiple —

Welding Current: A.C. — D.C.E.N.(—) — D.C.E.P.(+) X

Root Treatment 1/8" root opening Backing Material Ceramic Backing Backgouging N/A

Preweld Heat Treatment NONE Preheat Temperature NONE

Interpass Temperature NONE Postweld Heat Treatment NONE

Pass No.	Electrode Diameter (in.)	Welding Characteristics		Wire Feed Speed (IPM)	Travel Speed (IPM)	Stickout (in.)	Remarks
		Amperage	Volts				
1	.045"	200-290	24-30	300-360	6-13	3/4	Passes - Root & Fill
2							
3							
4							
5							
6							
7							
8							
9							
10							

Procedure No. WP-2

WELDING PROCEDURE SPECIFICATION

Material Specification 3/8" Carbon Steel Plate (ASTM A-36) to 4" dia. Carbon Steel Plate (ASTM A-53) and 1/2" Carbon Steel Plate (ASTM A-36)

Welding Process GMAW Transfer Mode Spray

Manual — Semi-Automatic X Automatic — Machine —

Weld Position: 1 F/G — 2 F/G X 3 F/G — 4 F/G — 5 G — 6G —

AWS Filler Metal Spec: A5.18 - 79 AWS Filler Metal Class: ER - 70S - 6

AWS Flux Spec N/A Weld Metal Grade N/A

Shielding Gas Composition Argon (98%)/Oxygen (2%) Flow Rate (CFH) 30-40

Passes: Single X Multiple — Arc: Single X Multiple —

Welding Current: A.C. — D.C.E.N.(—) — D.C.E.P.(+) X

Root Treatment N/A Backing Material N/A Backgouging N/A

Preweld Heat Treatment NONE Preheat Temperature NONE

Interpass Temperature NONE Postweld Heat Treatment NONE

Pass No.	Electrode Diameter (in.)	Welding Characteristics		Wire Feed Speed (IPM)	Travel Speed (IPM)	Stickout (in.)	Remarks
		Amperage	Volts				
1	.045"	200-250	24-30	280-360	6-13	3/4	Includes pipe & gusset
2							
3							
4							
5							
6							
7							
8							
9							
10							

Procedure No. WP-3

WELDING PROCEDURE SPECIFICATION

Material Specification 3/8" Carbon Steel Plate (ASTM A-36) to 3/8" Carbon Steel Plate (ASTM A-36)

Welding Process SMAW Transfer Mode N/A

Manual X Semi-Automatic — Automatic — Machine —

Weld Position: 1 F/G X 2 F/G — 3 F/G — 4 F/G — 5 G — 6G —

AWS Filler Metal Spec: A5.18 - 81 AWS Filler Metal Class: E7018

AWS Flux Spec N/A Weld Metal Grade N/A

Shielding Gas Composition Flow Rate (CFH) N/A

Passes: Single — Multiple X Arc: Single X Multiple —

Welding Current: A.C. x D.C.E.N.(—) — D.C.E.P.(+) x

Root Treatment 1/8" root opening Backing Material Ceramic Backing Backgouging N/A

Preweld Heat Treatment NONE Preheat Temperature NONE

Interpass Temperature NONE Postweld Heat Treatment NONE

Pass No.	Electrode Diameter (in.)	Welding Characteristics		Wire Feed Speed (IPM)	Travel Speed (IPM)	Stickout (in.)	Remarks
		Amperage	Volts				
1	1/8"	90-140 AC or DC			7-14		Passes - Root & Fill
2							
3							
4							
5							
6							
7							
8							
9							
10							

Procedure No. WP-4

WELDING PROCEDURE SPECIFICATION

Material Specification 1/4" Carbon Steel Plate (ASTM A-36) to 4" dia. Carbon Steel Plate (ASTM A-53)

Welding Process GTAW Transfer Mode N/A

Manual X Semi-Automatic — Automatic — Machine —

Weld Position: 1 F/G — 2 F/G — 3 F/G up 4 F/G — 5 G — 6G —

AWS Filler Metal Spec: A5.18 - 79 AWS Filler Metal Class: ER - 70S - 6

AWS Flux Spec N/A Weld Metal Grade N/A

Shielding Gas Composition Argon Flow Rate (CFH) 10-15

Passes: Single x Multiple — Arc: Single X Multiple —

Welding Current: A.C. — D.C.E.N.(—) x D.C.E.P.(+) —

Root Treatment N/A Backing Material N/A Backgouging N/A

Preweld Heat Treatment NONE Preheat Temperature NONE

Interpass Temperature NONE Postweld Heat Treatment NONE

Pass No.	Electrode Diameter (in.)	Welding Characteristics		Wire Feed Speed (IPM)	Travel Speed (IPM)	Stickout (in.)	Remarks
		Amperage	Volts				
1	3/32	90-190			8-14		Uses 3/32" dia. filler metal
2							Electrode AWS Spec. 5. EW Th-2
3							
4							
5							
6							
7							
8							
9							
10							

Procedure No. WP-5

WELDING PROCEDURE SPECIFICATION

Material Specification 3/8" Carbon Steel Plate (ASTM A-36) to 4" dia. Carbon Steel Plate (ASTM A-53) and 1/4" Carbon Steel Plate (ASTM A-36)

Welding Process SMAW Transfer Mode N/A

Manual X Semi-Automatic — Automatic — Machine —

Weld Position: 1 F/G — 2 F/G — 3 F/G — 4 F/G X 5 G — 6G —

AWS Filler Metal Spec: A5.1 - 81 AWS Filler Metal Class: E7018

AWS Flux Spec N/A Weld Metal Grade N/A

Shielding Gas Composition N/A Flow Rate (CFH) N/A

Passes: Single X Multiple — Arc: Single X Multiple —

Welding Current: A.C. — D.C.E.N.(—) — D.C.E.P.(+) X

Root Treatment N/A Backing Material N/A Backgouging N/A

Preweld Heat Treatment NONE Preheat Temperature NONE

Interpass Temperature NONE Postweld Heat Treatment NONE

Pass No.	Electrode Diameter (in.)	Welding Characteristics		Wire Feed Speed (IPM)	Travel Speed (IPM)	Stickout (in.)	Remarks
		Amperage	Volts				
1	1/8"	90-140 DC			7-14		Includes pipe & gusset
2							
3							
4							
5							
6							
7							
8							
9							
10							